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CDM
6000 Uptown Blvd., NE, Suite 200
Albuquerque, New Mexico 87110
tel: 505 243-3200
fax: 505 243-2700

March 18, 2005

Mr. Galen Buller
Water Division Director City of Santa Fe
801 W. San Mateo
Santa Fe, New Mexico 87505

Subject: MRC WTP Water Quality Studies and Evaluations Report
Report Volume 2

Dear Mr. Buller:

CDM is pleased to present the City with the *MRC WTP Water Qualities Studies and Evaluations Report – Volume 2*. This volume includes technical memoranda on:

- Regulatory Requirements (Appendix A)
- Water Quality Evaluations and Studies (Appendices B through I)
- Laboratory Results (Appendix J)

These memoranda document the testing that was completed and serves as a backup to the material presented in Volume 1 of the Report.

We wish to acknowledge the valuable assistance the City's staff has provided in completing this project. In particular, we would like to thank the Canyon Road WTP staff for their help in obtaining samples, providing water quality data, and assisting in testing.

We look forward to working with the City and the County on this important facility.

Sincerely,

Mark D. Ryan

Mark Ryan, P.E.
Project Manager
Camp Dresser & McKee Inc.

O:\1257-32934 Santa Fe Water Supply Plan\Water Quality Testing\Reports\Final Appendices Vol 2\Letter Vol 2.doc

Contents

Appendices

APPENDIX A
REGULATORY REQUIREMENTS REVIEW TECHNICAL MEMORANDUM

CDM

Technical Memorandum

MRC WTP Water Quality Studies and Evaluations Project Regulatory Requirements Review

March 18, 2005

Summary

Purpose

The purpose of this memorandum is to summarize the regulations that apply to the design and operation of the proposed MRC Water Treatment Plant.

Conclusions

Most all of the existing and proposed regulations will have a significant impact on the design and operation of the MRC Water Treatment Plant. Consideration of the more stringent Maximum Contaminant Levels and other standards and requirements dictate the selected processes, their design and the treatment goals for the plant.

Background

CDM was contracted to complete a water quality study and evaluation related to the MRC WTP. Review and evaluation of water quality regulations affecting the design of the MRC WTP were completed and is outlined in this technical memorandum. Additional information regarding the regulatory requirements can be found in the EE&T Final Engineering Report (dated June 2002) titled *Compliance Audit of Surface Water Treatment Plant and Well Systems for the Sangre de Cristo Water Division*, as well in the supplemental technical memoranda prepared by CDM for the *MRC WTP Water Quality Studies and Evaluations Project*.

Regulatory Overview

Drinking water quality is regulated by the United States Environmental Protection Agency (EPA) and the New Mexico Environmental Improvement Board (NM EIB) Drinking Water Standards 20 NMAC 7.1 through a number of existing regulations. New regulations were recently promulgated by the EPA and additional regulations are currently under development. The goals of these regulations are to improve water quality and minimize risks to public health.

The WTP design must allow Santa Fe to easily comply with all applicable regulations. Therefore, the proposed and anticipated regulations all must be considered during design of the MRC WTP. Table 1 presents a list of the current and anticipated water quality regulations that will affect the design of the MRC WTP.

Table 1. Key Existing or Expected Water Quality Regulations Affecting Design of the MRC WTP

Regulation	Year Promulgated	Compliance Date
Total Coliform Rule (TCR)	1988	1991
Surface Water Treatment Rule (SWTR)	1989	1992
Lead and Copper Rule	1991	1994
Interim Enhanced Surface Water Treatment Rule (IESWTR)	1998	Jan 2002
Stage 1 Disinfectants/Disinfection By-Products Rule (DBPR)	1998	Jan 2002
Radionuclides Rule	2000	Dec 2003
Arsenic Rule	2001	Jan 2006
Filter Backwash Recycling Rule	2001	Jun 2004
Long Term 2 Enhanced SWTR (LT2ESWTR)	Early to mid-2005	2008
Stage 2 DBPR	Early to mid-2005	2008
National Primary and Secondary Drinking Water Standards	Multiple	3 years after promulgation of an added standard

The regulations dictate drinking water quality requirements such as maximum contaminant levels (MCLs) and levels of treatment. These regulations form the basis of the water treatment goals of the new MRC WTP. The water treatment goals and the Rio Grande water quality must be analyzed together as a basis for the selected unit processes and the design criteria for the WTP. The next section discusses each of the key regulations.

Key Water Quality Regulations

A brief discussion of each of the regulations affecting the design of the MRC WTP is presented in this section.

Total Coliform Rule

The Total Coliform Rule (TCR) was promulgated by EPA in June 1989 and applies to all public water systems. The purpose of the TCR is to improve public health protection by reducing fecal pathogens to minimal levels by early identification of potential contamination problems in a distribution system through routine total coliform monitoring. The TCR establishes a MCL goal (MCLG) of zero for total coliforms. The TCR requires routine monthly sampling at each established distribution sampling point (the number is based upon the served population) and analysis for total coliforms. If any sample is positive for total coliform, *E.Coli* and fecal coliform must be determined for the sample. Additionally, resampling and analysis is necessary. Santa Fe is in violation of the TCR if more than 5 percent of the routine and repeat samples in a month are total coliform positive or if **any** repeat sample is *E. Coli* or fecal coliform positive or if any routine sample is *E. Coli* or fecal coliform positive and followed by a total coliform positive repeat sample.

It is highly likely that the Rio Grande water, the water source for the MRC WTP, will contain *E. Coli* and fecal coliforms because of cattle grazing and other activities upstream of the diversion. Unfortunately, existing Rio Grande water quality data by the USGS at Otowi gaging station or by Boyle Engineering just north of Otowi for the San Ildefonso Collector

Well Demonstration Project does not include any fecal coliform or *E. Coli* testing results to confirm the potential contamination risk. The plant must be designed to fully disinfect ambient fecal matter coliforms so it does not enter the distribution system, resulting in TCR violations.

Surface Water Treatment Rule

The Surface Water Treatment Rule (SWTR) was promulgated in 1989 by EPA and the NM EIB. The SWTR includes requirements for removal and inactivation of viruses and *Giardia*, finished water (i.e., plant effluent) disinfection residual, and finished water turbidity. Filtration and disinfection must provide at least 3-log (99.9 percent) *Giardia* removal/inactivation, and 4-log (99.99 percent) virus removal/inactivation. The SWTR allows a conventional sedimentation/filtration treatment plant like proposed for the MRC WTP a set log removal credit of 2.5-log for *Giardia*, and 2-log for viruses. The remaining inactivation of 0.5-log for *Giardia* and 2-log for viruses must be met by chemical disinfection. Credit for disinfection is determined by the Ct value (disinfection residual concentration "C" multiplied by the disinfection contact time "t"). SWTR turbidity provisions require a plant to meet a finished water turbidity of less than 0.5 NTU in 95% of the samples and not to exceed 5.0 NTU in any samples. Turbidity monitoring must be accomplished by continuous monitoring or grab samples every four hours. A summary of the SWTR requirements are shown in Table 2. Figure 1 shows a general WTP process train with the applicable credit and requirements of the SWTR.

Table 2. Summary of SWTR Microbial Requirements

Microorganism	MCLG	MCL	Notes
Giardia lamblia	zero	TT	Treatment must achieve 3-log (99.9%) removal/inactivation
Virus	zero	TT	Treatment must achieve 4-log (99.99%) removal/inactivation
Legionella	zero	TT	N/A
Heterotrophic plate count	n/a	TT	Analytic method to measure the variety of bacteria; concentrations indicate measure of water system operations
Turbidity	n/a	TT	(1) Combined filtered water turbidity ≤ 0.5 NTU in at least 95% of monthly samples (2) Combined filtered water turbidity never to exceed 5 NTU

TT – Treatment technique : required process intended to reduce the level of contaminant.

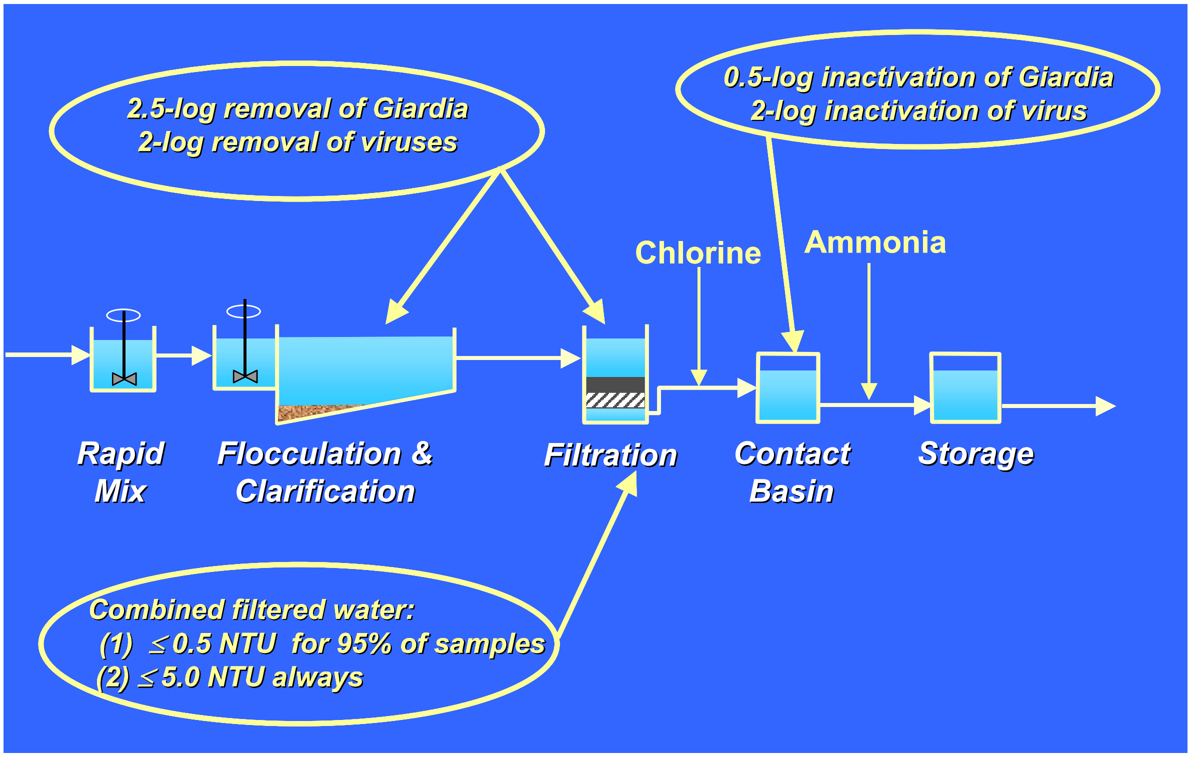

Figure 1. Example Treatment Train with SWTR Credits and Requirements

The SWTR requirements are important for the design of the plant since this rule, in conjunction with later rule enhancements, affects what unit processes and their design criteria are required to meet the disinfection contact times and microbial removal requirements through the plant.

Lead and Copper Rule

The Lead and Copper Rule (LCR) was promulgated in 1991 to address health concerns associated with elevated levels of lead and copper in drinking water. If the water characteristics and conditions are right, the water in the distribution system can corrode the metal piping resulting in elevated concentrations of metals, including lead and copper, in the drinking water. The LCR requires systems to complete a corrosion study of the system and monitor lead and copper at entry points to the distribution system and at a specified number of taps within homes and/or businesses served by the water system. The LCR also establishes treatment techniques requirements including corrosion control treatment, source water treatment, lead service line replacement, and public education.

The LCR set action levels of 0.015 mg/L and 1.3 mg/L for lead and copper, respectively. The treatment techniques requirements could be triggered if more than 10 percent of the samples exceed one or both of the action levels.

Because of the multiple water sources with differing water characteristics, introduction of a new water source into the system has the potential to disrupt the distribution system resulting in an exceedance of the action levels. Design of the MRC WTP must address the impacts on the distribution system from blending the water sources to minimize corrosion and or precipitation in the distribution system through the production of treated water compatible with the other sources.

Interim Enhanced Surface Water Treatment Rule

The Interim Enhanced SWTR (IESWTR) was published by EPA in December 1998. The rule was aimed at controlling waterborne pathogens, specifically *Cryptosporidium* and tightens the SWTR turbidity provisions. The rule added a 2-log removal/inactivation requirement for *Cryptosporidium*. However, the regulation allows a conventional sedimentation/filtration treatment plant a 2-log removal credit if turbidity requirements are met. The turbidity provisions were changed to reduce the previous maximum turbidity level of 5.0 NTU to 1.0 NTU and 95% of monthly samples must be less than or equal to 0.3 NTU. The rule also requires turbidity monitoring of individual filters. Table 3 shows how the IESWTR changed the SWTR; the changes are highlighted.

Table 3. Summary of Changes to SWTR Microbial Requirements by the IESWTR

Microorganism	MCLG	MCL	Notes
Cryptosporidium	zero	TT	Treatment must achieve 2-log (99%) removal/inactivation
Giardia lamblia	zero	TT	Treatment must achieve 3-log (99.9%) removal/inactivation
Virus	zero	TT	Treatment must achieve 4-log (99.99%) removal/inactivation
Legionella	zero	TT	N/A
Heterotrophic plate count	n/a	TT	Analytic method to measure the variety of bacteria; concentrations indicate measure of water system operations
Turbidity	n/a	TT	(1) Combined filtered water turbidity ≤ 0.3 NTU in at least 95% of monthly samples (2) Combined filtered water turbidity never to exceed 1 NTU

TT – Treatment technique: required process intended to reduce the level of contaminant.

Design of the MRC WTP must consider removal of *Cryptosporidium*, which likely is present in the source water. This IESWTR, and other regulations, will dictate what log removal of *Cryptosporidium* is required and thus what treatment unit processes and design criteria will be used for plant design. Refer to the discussion on the Long Term 2 Enhanced SWTR presented later in the memorandum for additional information on *Cryptosporidium*. Additionally, meeting the lower turbidity requirements will require more effective solids removal and filtration than was required under the SWTR.

Stage 1 Disinfectants/Disinfection By-Products Rule

The Stage 1 Disinfectants/Disinfection By-Products Rule (DBPR) was published by the EPA in December 1998. It lowered the threshold for total organic carbon (TOC), established MCLGs and MCLs for disinfection by-products (DBPs), and set maximum residual disinfectant levels (MRDLs) for disinfectants. The goal of the Stage 1 DBPR is to protect against health risks associated with certain DBPs from the operation of water treatment plants. Systems must monitor and control the use of disinfectants and meet new requirements for total trihalomethanes (TTHM), the sum of five haloacetic acids (HAA), and bromate and chlorite. MCLs for several DBPs are as follows:

- TTHM - 80 μg/L
- HAA - 60 μg/L
- Bromate - 10 μg/L
- Chlorite - 1.0 mg/L

In an effort to control DBPs, steps may need to be taken to reduce TOC concentrations through the use of enhanced coagulation or enhanced softening. The regulation sets a minimum percent of TOC removal based upon the source water TOC content and the source water alkalinity. Systems using conventional treatment must meet TOC removal requirements unless they meet any of the exception criteria including an annual source water TOC of less than 2.0 mg/L. Table 4 presents the required removal of TOC based on the source water TOC and alkalinity.

Table 4. TOC Removal Requirements under the Stage 1 DPBR

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L as $CaCO_3$)		
	0 - 60	>60 - 120	>120
2.0 - 4.0	35	25	15
>4.0 - 8.0	45	35	25
>8.0	50	40	30

Otowi Gaging Station water quality data collected by the USGS between 1990 and 2001 indicate that the TOC in the Rio Grande ranges from a low of 1.1 to a high of 20.7 mg/L, with an average of 5.4 mg/L. The three samples collected during the water quality testing performed by CDM ranged from 2.4 to 5.6 mg/L resulting in an average of 3.7 mg/L. The Otowi data show an alkalinity range from 62 to 128 mg/L with an average of approximately 100 mg/L. The water quality testing data confirmed alkalinity was within the historic range and ranged from 69 to 130 mg/L with an average of 100 mg/L. Therefore, from the available data, the required TOC removal based upon the running annual average of source water TOC and alkalinity will average 35 percent but could range from 25 to 40 percent. The regulation requires compliance to be demonstrated with paired TOC samples collected at least monthly from raw water and combined filter effluent with a raw water alkalinity sample collected at the same time. The regulation also allows for a system to demonstrate compliance based upon alternative compliance criteria. If removal of TOC proves too expensive and prohibitive, investigation of the other treatment methods is suggested.

As with the other regulations, the Stage 1 DBPR requirements affect the selection of the unit processes as well as the design criteria. Free chlorine based disinfectants are unlikely to be selected to comply with this and other regulations. The changing source water quality will require operational flexibility to be designed into the plant to allow for enhancing coagulation to increase the percentage of TOC removal as required. Additional information on TOC removal requirements can be found in the CDM technical memorandum titled *MRC WTP Water Quality Studies and Evaluation Project Organics and TOC Evaluation.*

Radionuclides Rule

The Radionuclides Rule, published by EPA on December 7, 2000, for regulating and reducing the exposure to radionuclides in drinking water, regulates the concentration of uranium as required by the 1986 amendments to the SDWA, and retains the existing standards for other contaminants. Systems will be required to comply with the monitory requirements of the rule. Systems began initial (quarterly) monitoring under a State specified plan on December 8, 2003, the effective date for the rule. However, grandfathered data may be used to comply with the initial monitoring requirements under certain circumstances. The MCLs for the regulated radionuclides are summarized in Table 5.

Table 5. Radionuclide Rule Maximum Contaminant Levels

Radionuclide	MCL
Beta/photon emitters	4 mrem/year
Gross alpha particle	15 pCi/L
Radium-226 and Radium-228	5 pCi/L
Uranium	30 μg/L

Samples for quarterly analysis will be collected at each entry point to distribution systems. The results of the initial monitoring will trigger either a decreased or an increased monitoring frequency based on the requirements summarized in Table 6.

All systems must complete initial monitoring by December 31, 2007, and comply with the monitoring frequency determined by the state after that period. This also is the deadline for systems to implement technologies, management, or other options that may be necessary to comply with the lowered uranium MCL.

Table 6. Monitoring Frequency

Initial Monitoring Results	Frequency of sampling
< detection limit	1 sample in 9 years
> detection limit, < ½ MCL	1 sample in 6 years
>½ MCL, < MCL	1 sample in 3 years
> MCL	Continue quarterly sampling until 4 consecutive samples are < MCL

Arsenic Rule

EPA promulgated a lower arsenic MCL in January 2001 - this new regulation is commonly referenced as the "Arsenic Rule." The Arsenic Rule lowered the standard from 50 µg/L to 10 µg/L (total arsenic). The rule outlined initial compliance sampling requirements. Surface water systems must complete initial compliance monitoring by December 1, 2006 (or earlier if grandfathered data is used). Groundwater systems must complete initial compliance monitoring by December 1, 2007. The Arsenic Rule also clarified compliance determination for inorganic contaminants, volatile organic contaminants and synthetic inorganic contaminants monitoring such that if the required number of samples are not collected, compliance with be based upon the actual number collected. Additionally, of specific importance to the Buckman Direct Diversion Project, the Arsenic Rule stated that systems using new sources of water must demonstrate compliance within State-specified time and sampling frequencies.

The State of New Mexico's Arsenic Compliance Strategy (August 2004) details exemption and variance procedures. An exemption allows systems serving more than 3,300 people an additional three years to obtain compliance. A variance allows a water system to comply with an alternate MCL for a limited time but eventual compliance with the new standard will be required. An exemption or variance request must be submitted to the Drinking Water Bureau by July 1, 2005 to guarantee sufficient review time by the new standard's compliance date of January 23, 2006. The exemption or variance request requires a significant amount of information to support the need for the request. Information includes the compelling factors preventing compliance, strategy and schedule for compliance, and financial and funding information.

Elevated arsenic concentrations are most often associated with groundwater sources. Some existing Buckman Wells do have elevated arsenic concentrations. For operation flexibility and for overall system compliance with the Arsenic Rule, the potential use of the MRC WTP for treatment of the groundwater with elevated arsenic concentrations may be a feasible option. Additionally, Rio Grande source water may contain naturally-occurring arsenic. Therefore, this rule is an important consideration in plant design.

Filter Backwash Recycle Rule (FBRR)

The EPA promulgated the Filter Backwash Recycle Rule (FBRR) on May 30, 2001. The requirements and compliance schedule, as presented in the EPA Technical Fact Sheet, are presented below.

The FBRR applies to all public water systems that:

1) use surface water or ground water under the direct influence of surface water (GWUDI);
2) use direct or conventional filtration processes; and
3) recycle spent filter backwash water, sludge thickener supernatant, or liquids from dewatering processes.

The FBRR requires that recycled filter backwash water, sludge thickener supernatant, and liquids from dewatering processes must be returned to a location such that all processes of a system's conventional or direct filtration including coagulation, flocculation, sedimentation (conventional filtration only) and filtration, are employed. Systems may apply to the State for approval to recycle at an alternate location. This rule must be considered during design of the MRC WTP to ensure full treatment of the recycle occurs.

Long-Term 2 Enhanced Surface Water Treatment Rule

The Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) is an EPA drinking water regulation that EPA proposed on August 11, 2003. The comment period for the proposed rule closed on January 9, 2004, and the rule will be promulgated early to mid-2005. The EPA's intent is to provide more uniform public health protection by linking the level of required water treatment to the level of source water contamination. The objective is to determine the concentration of *Cryptosporidium* in a plant's source water and to designate the appropriate treatment requirements.

LT2ESWTR will apply to medium and large filtered systems (greater than or equal to 10,000 people served) using surface water, including both community and non-community systems. This is estimated to include approximately 2,000 WTPs nationwide. Ground water systems (not under the influence of surface water) are exempt from LT2ESWTR, as are surface water systems that already provide greater than or equal to 5.5-log removal of *Cryptosporidium*.

LT2ESWTR will initially require monthly sampling and testing for *Cryptosporidium*, *E. Coli*, and turbidity of the source water for 24 consecutive months. Giardia is also analyzed with the EPA approved *Cryptosporidium* test method at no additional cost. CDM prepared a *Cryptosporidium* sampling protocol for the City's use in collecting data for use in the MRC WTP. City staff began collecting water samples for *Cryptosporidium* analysis in August 2003.

Based upon the monitoring, the system will receive a "Bin Classification." The water quality will determine the appropriate Bin Classification for Rio Grande source water and required additional treatment. Recognizing that filtration plants meeting turbidity requirements will receive a 2-log *Cryptosporidium* removal credit under the IESWTR. The LT2ESWTR Bin Classification dictates what additional removal is required, if any. Table 7 presents the Bin Classification and additional removal requirement based upon average *Cryptosporidium* concentration.

Table 7. LT2ESWTR *Cryptosporidium* Bin Classifications

Bin #	Average *Cryptosporidium* Concentration	Additional Treatment Requirements[1]
1	< 0.075/L	No Action
2	0.075/L - <1.0/L	1.0-log Treatment
3	1.0/L - < 3.0/L	2.0-log Treatment
4	> 3.0/L	3.0-log Treatment

[1]Over and above conventional treatment that complies with IESWTR

As can be seen from Table 7, determining the Bin Classification of the Rio Grande source water is critical for design of the water treatment plant. The plant could be easily under- or over-designed if the preliminary Bin Classification is not accurate. The regulation outlines a "microbial toolbox" with options that can be implemented to meet the additional removal requirements under the system's Bin Classification. Some options have a set credit while others are based upon plant specific criteria. Systems that use ozone, chlorine, UV, or membrane and conventional treatment may receive credit toward Bin requirements based upon plant specific criteria.

Table 8 provides a summary of the Microbial Toolbox and it's applicability to the MRC WTP design. Additional information regarding the Bin Classification can be found in the CDM technical memorandum titled *MRC WTP Water Quality Studies and Evaluation Project Cryptosporidium / Microbial Study Testing and Results.*

Table 8. EPA Microbial Toolbox Options for the LT2ESWTR

Toolbox Option	Proposed Credit	Applicable to MRC WTP Design?
Pre-Sedimentation Basin with Coagulation	0.5-log	Yes, can be added to conventional treatment train
Lower Finished Water Turbidity	0.5-log for CFE <0.15 in 95% samples per month 1.0-log for individual filters <0.15 in 95% samples per month	Yes, within capabilities of a well-designed and –operated conventional treatment facility
Second Stage Filtration	0.5-log	Yes, but requires additional capital cost
Membranes	Credit equal to demonstrated removal efficiency in challenge test	Yes
Chlorine Dioxide	Credit based on CT table	Yes
Ozone	Credit based on CT table	Yes
UV	Credit based on demonstration of compliance with UV dose table	Yes
Demonstration of Performance	1.0-log based on average spore removal 4-log based on 1 year of weekly monitoring	Yes

Stage 2 Disinfectants/Disinfection By-Products Rule

The proposed Stage 2 DBRP was published in the Federal Register on August 18, 2003. The comment period closed on May 15, 2004, with the rule likely being finalized in summer 2005. The Stage 2 DBPR will supplement other regulations by requiring systems to meet DBP MCLs at each monitoring site in the distribution system, rather than in the system as a whole based on a running annual average (RAA). Systems will conduct an evaluation of their distribution system to identify the locations with high DBP concentrations. These locations will be used for DBP compliance monitoring. Compliance will be based on a Locational Running Annual Average (LRAA) in two different stages. During the first stage (2A), the LRAA will be calculated for the system's existing monitoring locations. During the second stage (2B), the system must monitor at the compliance monitoring locations identified from the evaluation that identified the points with highest DBP concentrations. Table 9 summarizes the Stage 2 DBPR requirements.

Table 9. Stage 2 DBPR Requirements

Disinfection By-Product	Maximum Contaminant Levels (mg/L)		
	Stage 2A (2008)[1]		Stage 2B (2011)
	RAA	LRAA	LRAA
THM	0.080	0.120	0.080
HAA	0.060	0.100	0.060

[1]Early anticipated compliance date, 3-year extension for capital improvement projects

This rule requires that the selected disinfectant(s) used at the MRC WTP be carefully chosen to not cause compliance problems with the portion of the distribution system served by this facility. The hypochlorite based disinfectant (MIOX) used at other City facilities such as the Canyon Road Water Treatment Plant may not be capable of controlling formation of these DBP concentrations when TOC levels are potentially high. Additional information regarding the DBP concentrations can be found in the CDM technical memorandum titled *MRC WTP Water Quality Studies and Evaluation Project Disinfection By-Product Study.*

National Primary and Secondary Drinking Water Regulations

Drinking water standards are regulations that EPA sets to control the level of contaminants in the nation's drinking water. These standards are part of the Safe Drinking Water Act's "multiple barrier" approach to drinking water protection, which includes assessing and protecting drinking water sources; protecting wells and collection systems; making sure water is treated by qualified operators; ensuring the integrity of distribution systems; and making information available to the public on the quality of their drinking water. These standards were developed under the provisions of the Safe Drinking Water Act and the subsequent 1986 and 1996 amendments. Most of these standards have been previously discussed and were adopted under specific rules such as the DBPR and the Arsenic Rule.

There are two categories of drinking water standards:

- A National Primary Drinking Water Regulation (NPDWR or primary standard) is a legally- enforceable standard that applies to public water systems. Primary standards protect drinking water quality by limiting the levels of specific contaminants that can adversely affect public health and are known or anticipated to occur in water. They take the form of MCLs or Treatment Techniques. Currently, there are primary standards for over 90 contaminants.
- A National Secondary Drinking Water Regulation (NSDWR or secondary standard) is a non-enforceable guideline regarding contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards. New Mexico does not enforce secondary standards. Approximately 15 contaminants are on the EPA secondary standards list.

The contaminant-specific MCLs are not discussed in this memorandum. Rather, the applicable MCL is discussed as it is applies to each evaluation. For instance, the contaminants study technical memorandum includes a listing of the measured contaminant's MCL for comparison with the laboratory results.

APPENDIX B
CRYPTOSPORIDIUM/MICROBIAL STUDY TESTING AND RESULTS
TECHNICAL MEMORANDUM

Technical Memorandum

MRC WTP Water Quality Studies and Evaluations Project *Cryptosporidium* / Microbial Study Testing and Results

March 18, 2005

Summary

Purpose

The purpose of this memorandum is to evaluate the average *Cryptosporidium* concentration in the proposed source water for the Municipal Recreation Complex (MRC) Water Treatment Plant (WTP). Using this information, the Bin Classification for *Cryptosporidium* removal, in accordance with the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), can be determined. The Bin Classification estimate will be used in developing the MRC WTP.

Conclusions

Cryptosporidium is prevalent in many source waters and removal in water treatment is essential to protect the public's health. Based on the results of this study a Bin Classification of 2 (an additional 1-log removal of *Cryptosporidium* above the 2-log removal requirement satisfied by filtration), will be necessary at the MRC WTP. This Classification is based upon the limited sampling and testing data performed for the Buckman Direct Diversion Project and the requirements specified in the proposed LT2ESWTR.

Background

Cryptosporidium is a microorganism commonly found in lakes and rivers and is highly resistant to typical disinfection practices. *Cryptosporidium* has periodically caused large outbreaks of gastrointestinal illness, with symptoms that include diarrhea, nausea, and/or stomach cramps. The immune-compromised portion of the population often exhibit much more serious healthy effects. Therefore, removal of *Cryptosporidium* from public drinking supplies is essential for water treatment plants (WTPs) across the United States with susceptible source waters.

In the summer of 2003, the United States Environmental Protection Agency (EPA) proposed a new drinking water regulation with the objective of determining the level of source water *Cryptosporidium* contamination and the appropriate level of treatment. With the intent of providing more uniform public health protection, the new regulation, titled the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), is to be promulgated by early to mid 2005. Additional information regarding the LT2ESWTR can be found in the CDM technical memorandum titled *MRC WTP Water Quality Studies and Evaluation Project Regulatory Requirements Review and Evaluation.*

LT2ESWTR will apply to medium and large filtered systems (greater than or equal to 10,000 people served), using surface water, including both community and non-community systems. This is estimated to include approximately 2,000 WTPs nationwide. Groundwater systems (not under the influence of surface water) are exempt from LT2ESWTR, as are surface water systems that already provide greater than or equal to 5.5-log removal of *Cryptosporidium*.

With respect to the LT2ESWTR, one removal credit equals 1-log of additional inactivation beyond treatment required under the Surface Water Treatment Rule. Different types of treatment process are assigned certain removal credits. The different types of drinking water disinfection processes (conventional filtration, ozonation, membrane filtration, etc.) are assigned a credit value. Therefore, if the EPA requires a 3-log removal, the water must proceed through enough processes until 3 credits of inactivation are attained. For example, 2-log equals an additional 99 percent removal and 3-log equals 99.9 percent removal of *Cryptosporidium*. Additional information regarding the log and credit assignments is presented in the following sections.

LT2ESWTR will initially require monthly sampling and testing for *Cryptosporidium*, *E. coli*, and turbidity of the source water for 24 consecutive months. *Giardia,* another common microorganism found in lakes and rivers, is also analyzed with the EPA approved *Cryptosporidium* test method (EPA Test Method 1623) at no additional cost. The grandfathering of data is not guaranteed as the LT2ESWTR has not yet been promulgated. However, published EPA information entitled "*Guidance on Generation and Submission of Grandfathered Cryptosporidium Data for Bin Classification Under the Long-Term 2 Enhanced Surface Water Treatment Rule,"* April 2003, (hereinafter referred to as EPA Guidance) gives an early indication that the data would be acceptable if it meets EPA requirements for sampling and analysis.

For this study, monthly sampling and testing for *Cryptosporidium* and turbidity was conducted over a seven month period. The following section includes the recommended protocol as required for grandfathering of data collection.

Recommended Protocol

The following protocol is based upon EPA Guidance. In order for the *Cryptosporidium* data to be grandfathered by the EPA under the LT2ESWTR the protocol must be followed exactly. Either EPA Test Method 1622 (*Cryptosporidium)* or EPA Test Method 1623 (*Cryptosporidium* and *Giardia*) can be used for laboratory analyses.

Sampling Schedule

Sampling is required once per month for a period of two years (24 total samples) from the planned source water. Samples should be taken at the same time each month (i.e. first of each month) with 30 days between each sampling period. EPA recommends that WTPs develop a sampling schedule listing the calendar date on which each *Cryptosporidium* sample will be collected. This schedule should be prepared prior to initiation of monitoring. Samples should be collected within 2 days before or after the dates indicated in the sampling schedule.

Exceptions to the sampling schedule include the following:

- If the sample cannot be collected for safety or other unforeseen reasons, the sample should be collected as close to the originally scheduled date as possible and an explanation for the schedule deviation should be prepared for inclusion with the laboratory results.
- If an analytical method quality control standard compliance failure (sample is lost or contaminated, laboratory exceeds holding time, or one of the three testing constraints discussed below can not be met), a replacement sample should be collected within 14 days of being notified by the laboratory of the analytical problems. An explanation for the schedule deviation should be prepared for inclusion with the laboratory results.
- If the regular sampling dates occur during a rain event, this should be documented. During the period of sampling, if a rain event occurs between regular sampling dates, a sample should be taken immediately to capture this runoff event. A total of 3 to 4 samples during rain events is preferred and may consist of a combination of regular sampling dates and rain events between regular sampling dates.

Alternative or adjusted sampled collection dates should be timed so as not to coincide with another scheduled *Cryptosporidium* sample collection date.

Grandfathering Data

In order for the *Cryptosporidium* data to be grandfathered by the EPA for the LT2ESWTR, one of the following three constraints must be met for each sample:

- <u>The entire 10-liter sample must be analyzed for the *Cryptosporidium* concentration by EPA Test Method 1622 or 1623:</u> The 10-liter bulk water sample is filtered (in the laboratory) utilizing one filter only. The *Cryptosporidium* oocysts, cysts, and extraneous materials are retained on the filter. The fluid is then discarded and the material on the filter is analyzed.
- <u>Two "clogged filters" must be analyzed for the *Cryptosporidium* concentration by EPA Test Method 1622 or 1623:</u> The bulk water sample is filtered (either in the field or in the laboratory) until water cannot pass through (i.e. "clogged"). The *Cryptosporidium* oocysts, cysts, and extraneous materials are retained on the filter. The fluid is then discarded and the material on the filter is analyzed (a minimum of two filters).

- Four "packed pellet volumes" must be analyzed for the *Cryptosporidium* concentration by EPA Test Method 1622 or 1623: The material on the filter is eluted and centrifuged (i.e. "packed"). The pellet generated using in the centrifuge contains the *Cryptosporidium* oocysts, cysts, and extraneous materials. The fluid is then discarded and the pellet is analyzed (a minimum of four pellets). However, each pellet volume may not exceed 0.5 milliliter for each test.

Laboratory Results

The water utilized for sampling was collected on a monthly basis, beginning in August 2003, from the proposed location of the Buckman Direct Diversion Project Intake Structure on the Rio Grande. The water samples were sent to Assaigai Analytical Laboratories (Albuquerque, NM) for analyses of turbidity by EPA Test Method 180.1. The samples were then sent to CH Diagnostic and Consulting Service Inc. (Loveland, CO) for analyses of *Cryptosporidium* and *Giardia* concentrations by EPA Test Method 1623.

For each source water sample the location, depth and temperature were recorded before a 10-liter sample was collected. The samples were then appropriately labeled, packed in a cooler with ice, and shipped to the laboratory with the pertinent paperwork. A summary of the analytical laboratory analyses is presented in Table 1 below and copies of the laboratory reports are included in Appendix A.

Table 1. Summary of *Cryptosporidium* and *Giardia* Concentrations

Sample Date	Volume Tested (Liter)	Turbidity (NTU)	*Cryptosporidium*		*Giardia*		River Daily Flow (cfs)
			# Detected[1]	# / Liter[2]	# Detected[1]	# / Liter[2]	
08/13/03	7.0	150	0	0	3	0.4	481
08/25/03[3]	9.0	117	0	0	63	7	966
09/11/03	0.0984	2590	0	0	1	10	774
10/09/03	2.0	71.2	0	0	24	12[4]	372
11/06/03	6.116	16.1	1	0.2	68	11[4]	382
12/04/03	5.0	25.3	0	0	19	4	600
01/06/04	10.0	7.8	0	0	23	2	385

NTU = Nephelometric Turbidity Unit
cfs = Cubic Feet per Second
[1]Detected = Includes all oocysts and cysts of *Cryptosporidium* or *Giardia* observed, respectively, using EPA Test Method 1623.
[2]Laboratory presents *Cryptosporidium* concentration (#/L) as detection limit (see laboratory report).
[3]Sample was collected after a rain event on 08/25/03.
[4]Laboratory results are rounded to the nearest 10 (see laboratory report).

Although 24 months of data were not collected, which is required by the EPA for determination of the WTP Bin Classification, the values can still be utilized for a generalization of the 12-month *Cryptosporidium* average concentration. The average (or mean) *Cryptosporidium* concentration for this study is calculated as 0.03 per liter, based upon the seven discrete samples.

Discussion of Results

Per the proposed LT2ESWTR, the WTP Bin Classification ultimately dictates the level of treatment, and types of treatment, required for the MRC WTP. Table 2 below presents the distinction between the proposed EPA Bin Classifications.

Table 2. Bin Classifications by Mean *Cryptosporidium* Concentrations and Required Additional Source Water Treatment

Bin	Mean *Cryptosporidium* Concentration	Requirements
1	Less than 0.075/Liter (L)	No additional treatment required[1]
2	Greater than or Equal to 0.075/L, but Less than 1.0/L	1 log additional treatment[2]
3	Greater than or Equal to 1.0/L, but Less than 3.0/L	2 log additional treatment[3]
4	Greater than or Equal to 3.0/L	2.5 log additional treatment[3]

[1]Beyond treatment required under existing Surface Water Treatment Rule (SWTR).

[2]Public Water Supply (PWS) may use any technology or combination of technologies from the toolbox. (See Draft Rule for Toolbox explanation).

[3]Greater than or equal to 1 log of the required additional treatment from ozone, chlorine dioxide, UV, membranes, bag/cartridges, or bank filtration.

A Bin Classification, according to the EPA, is the level of additional treatment required. Based upon the collected data and the average *Cryptosporidium* concentration of 0.03 per liter, the WTP must comply with Bin Classification 1. However, due to the limited data, a Bin Classification 2, 1-log additional treatment, is recommended for the MRC WTP. As mentioned above, the collected data can be utilized for preliminary design of the WTP. Although only seven months of data were collected, the data is likely representative of the worst conditions in the river. The river flows at the sampling time ranged from 372 to 966 cfs, as shown in Table 1 and as recorded by the USGS Otowi Gaging Station just upstream of the proposed Buckman Diversion Structure location. The lower flow (372 cfs) is near the normal low flow in the river. Although the highest flow (966 cfs) is significantly lower than the normal high flows, it occurs during a rain storm likely increasing the *Cryptosporidium* concentration. This "worst-case" assignment (Bin Classification 2) for the drinking water treatment will greatly minimize the public's exposure to harmful levels of the *Cryptosporidium* microorganism.

The Rio Grande has a significant sediment concentration that affected the ability of the laboratory to process the minimum ten liters of water with one filter and/or one pellet. Completing the laboratory analyses to meet either of the other criteria (two clogged filters or four packed pellets) increased the cost of the analyses tremendously. Because of the City's budgetary limitations only one of the seven tests met the criteria that would allow the data to be grandfathered. According to discussions with EPA, the sampling location for the MRC WTP will likely be the pre-sedimentation facility discharge, which does not yet exist.

Therefore, there is no value or need to report this testing data to EPA for grandfathering under LT2ESWTR. The intent of the study was to select the appropriate Bin Classification for water treatment, not to incorporate grandfathering of the data. However, the data will be useful for future considerations regarding the source water for the Buckman Direct Diversion Project.

Appendix A
Analytical Laboratory Results

ASSAIGAI ANALYTICAL LABORATORIES, INC.
4301 Masthead NE • Albuquerque, New Mexico 87109 • (505) 345-8964 • FAX (505) 345-7259
3332 Wedgewood, E-5 • El Paso, Texas 79925 • (915) 593-6000 • FAX (915) 593-7820
127 Eastgate Drive, 212-C • Los Alamos, New Mexico 87544 • (505) 662-2558

Dec sample collected 12/4/03

CITY OF SANTA FE
attn: GARY MARTINEZ
1780 CANYON RD.
SANTA FE NM 87501

Explanation of codes	
B	analyte detected in Method Blank
E	result is estimated
H	analyzed out of hold time
N	tentatively identified compound
S	subcontracted
1-9	see footnote

Assaigai Analytical Laboratories, Inc. STANDARD

Certificate of Analysis

Client: CITY OF SANTA FE
Project: RIO GRANDE RIVER
Order: 0308255 SANC9 Receipt: 08-13-03

William P. Biava: President of Assaigai Analytical Laboratories, Inc.

Sample: *#23 RIO GRANDE RIVER* Collected: *08-13-03 9:10:00* By: *JS*
Matrix: *G*

QC Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
0308255-01A		METHOD 6123								
							By:	CHD		
CHD20030661	SB.2003.525.1		Cryptosporidium	See Attached	#/L	1	0	S	08-16-03	08-16-03
CHD20030661	SB.2003.526.1		Giardia	See Attached	#/L	1	0	S	08-16-03	08-16-03

Sample: *#24 RIO GRANDE RIVER* Collected: *08-13-03 9:10:00* By: *JS*
Matrix: *G*

QC Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
0308255-02A		EPA 180.1 Turbidity, Nephelometric								
							By:	ML		
TU0336	WC.2003.2236.2		Turbidity	150	NTU	1	0.3		08-14-03	08-14-03

Unless otherwise noted, all samples were received in acceptable condition and all sampling was performed by client or client representative. Sample result of ND indicates Not Detected, ie result is less than the sample specific Detection Limit. Sample specific Detection Limit is determined by multiplying the sample Dilution Factor by the listed Reporting Detection Limit. All results relate only to the items tested. Any miscellaneous workorder information or footnotes will appear below.

MEMO Subcontracted to CH Diagnostic and Consulting Service, Inc.

ANALYSIS FOR WATERBORNE PARTICULATES

CH Diagnostic and Consulting Service, Inc.
214 SE 19th Street, Loveland, CO 80537
Brec L. Clay, President/Treasurer; Gregory D. Sturbaum, President/Secretary
(970) 667-9789

Invoice 20030661

Customer 960726
Assaigai Analytical Labs
4301 Masthead N.E.
Albuquerque, NM 87109

Laboratory Information
UPS; 8/14/03; 0950 Hrs; 6°C; carboy-4-3 liter
Results submitted by:
Brec L Clay President/Treasurer

Sample Identification: #23, Rio Grande River, Raw water

Sample Information: SOURCE: Stream or River

Sample Date & Time: 8/13/03 09:10 AM OK

Sampler: Jeff Salazar

Amount: 10 L

Filter Color: N/A

Filter Type: Filta-Max™ Filter

Date/Time Eluted: 8/16/03 08:55 AM

Centrifugate: 7 mL/100 L

Amount of sample assayed: 7 L

		Total IFA Count	Empty	Amorphous Structure	1 Internal Structure	>=2 Internal Structure	Internal Structure	DAPI+ (nuclei stained)	DAPI+ (Intense Internal staining)	DAPI-
Giardia	detected	3	0	1	2	0		0	0	3
	# / L	0.4	<0.1	0.1	0.3	<0.1		<0.1	<0.1	0.4
Cryptosporidium	detected	0	0	0			0	0	0	0
	# / L	<0.1	<0.1	<0.1			<0.1	<0.1	<0.1	<0.1

This sample was analyzed for *Giardia* and *Cryptosporidium* by the method outlined in: Method 1623: *Cryptosporidium* and *Giardia* in Water by Filtration/IMS/FA. April 2001. USEPA, Washington D.C., EPA-821-R-01-026. All limitations stated in the method apply. Detection limit calculated from volume assayed. If HV capsule or foam filter was received, method was modified by filtering sample through a Pall Envirochek™ HV capsule or IDEXX Filta-Max™ filter at the sample site. If Microscopic Particulate Analysis was also performed, particulate extraction was modified.

Packed pellet = 0.07 ...

ASSAIGAI ANALYTICAL LABORATORIES, INC.
4301 Masthead NE • Albuquerque, New Mexico 87109 • (505) 345-8964 • FAX (505) 345-7259
3332 Wedgewood, Ste. N • El Paso, Texas 79925 • (915) 593-6000 • FAX (915) 593-7820
127 Eastgate Drive, 212-C • Los Alamos, New Mexico 87544 • (505) 662-2558

Explanation of codes

B	analyte detected in Method Blank
E	result is estimated
H	analyzed out of hold time
N	tentatively identified compound
S	subcontracted
1-9	see footnote

CITY OF SANTA FE
attn: GARY MARTINEZ
1780 CANYON RD.
SANTA FE NM 87501

STANDARD

Assaigai Analytical Laboratories, Inc.

Certificate of Analysis

Client: CITY OF SANTA FE
Project: RIO GRANDE RIVER
Order: 0308494 SANC9 Receipt: 08-25-03

William P. Biava: President of Assaigai Analytical Laboratories, Inc

Sample: *#31 RIO GRANDE RIVER* Collected: *08-25-03 9:25:00* By: *JS*
Matrix: *G*

QC Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
0308494-01A		METHOD 6123					By:	CHD		
CHD20030704	SB.2003.567.1		Cryptosporidium	See Attached	#/L	1	0	S	08-28-03	08-28-03
CHD20030704	SB.2003.567.1		Giardia	See Attached	#/L	1	0	S	08-28-03	08-28-03

Sample: *#32 RIO GRANDE RIVER* Collected: *08-25-03 9:25:00* By: *JS*
Matrix: *G*

QC Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
0308494-02A		EPA 180.1 Turbidity, Nephelometric					By:	ML		
TU0341	WC.2003.2128.2		Turbidity	117	NTU	1	0.3		08-26-03	08-26-03

Unless otherwise noted, all samples were received in acceptable condition and all sampling was performed by client or client representative. Sample result of ND indicates Not Detected, ie result is less than the sample specific Detection Limit. Sample specific Detection Limit is determined by multiplying the sample Dilution Factor by the listed Reporting Detection Limit. All results relate only to the items tested. Any miscellaneous workorder information or footnotes will appear below.

Memo: Subcontracted to CH Diagnostic and Consulting Service, Inc.

SQLCoyote: Reports 1.0.0307301320XX *Report Date* 9/29/2003 12:27:34 PM

ACCREDITED

ANALYSIS FOR WATERBORNE PARTICULATES

Invoice 20030704

CH Diagnostic and Consulting Service, Inc.
214 SE 19th Street, Loveland, CO 80537
Broc L. Clay, President/Treasurer; Gregory D. Sturbaum, President/Secretary
(970) 667-9789

Customer 950726
Assaigai Analytical Labs
4301 Masthead N.E.
Albuquerque, NM 87109

Laboratory Information

UPS; 8/26/03; 0850 Hrs; 9°C; carboy 4-4L
Results submitted by:
Broc L. Clay President/Treasurer

Sample Identification: City of Santa Fe, #31, RG River, Raw water

Sample Information: SOURCE: Stream or River

Sample Date & Time: 8/25/03 09:25 AM OK **Sampler:** unrec.

Amount: 9 L **Filter Color:** N/A **Filter Type:** Filta-Max™ Filter

Date/Time Eluted: 8/26/03 08:31 AM **Centrifugate:** 4.44 mL/100 L

Amount of sample assayed: 9 L

		Total IFA Count	Empty	Amorphous Structure	1 Internal Structure	>=2 Internal Structure	Internal Structure	DAPI+ (nuclei stained)	DAPI+ (Intense internal staining)	DAPI-
Giardia	detected	63	0	56.7	6.3	0		0	0	63
	# / L	7	<0.1	6	0.7	<0.1		<0.1	<0.1	7
Cryptosporidium	detected	0	0	0			0	0	0	0
	# / L	<0.1	<0.1	<0.1			<0.1	<0.1	<0.1	<0.1

This sample was analyzed for *Giardia* and *Cryptosporidium* by the method outlined in: Method 1623: *Cryptosporidium and Giardia in Water by Filtration/IMS/FA*. April 2001. USEPA, Washington D.C., EPA-821-R-01-025 All limitations stated in the method apply. Detection limit calculated from volume assayed. If HV capsule or foam filter was received, method was modified by filtering sample through a Pall Envirochek™ HV capsule or IDEXX Filta-Max™ filter at the sample site. If Microscopic Particulate Analysis was also performed, particulate extraction was modified.

packed pellet = 0.04 mL

ASSAIGAI
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LABORATORIES, INC.
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3332 Wedgewood, Ste. N • El Paso, Texas 79925 • (915) 593-6000 • FAX (915) 593-7820
127 Eastgate Drive, 212-C • Los Alamos, New Mexico 87544 • (505) 662-2558

Explanation of codes

B	analyte detected in Method Blank
E	result is estimated
H	analyzed out of hold time
N	tentatively identified compound
S	subcontracted
1-9	see footnote

CITY OF SANTA FE
attn: GARY MARTINEZ
1780 CANYON RD.
SANTA FE NM 87501

STANDARD

Assaigai Analytical Laboratories, Inc.

Certificate of Analysis

Client: CITY OF SANTA FE
Project: RIO GRANDE RIVER
Order: 0309259 SANC9 Receipt: 09-11-03

William P. Biava: President of Assaigai Analytical Laboratories, Inc.

Sample: *#36 RIO GRANDE RIVER* Collected: *09-11-03 9:50:00* By: *JS*
Matrix: *G*

Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
0309259-01A		Method 1623					By:	CHD		
CHD20030748	SB.2003.581.1		Cryptosporidium	See Attached	# / L	1	0	S	09-12-03	09-12-03
CHD20030748	SB.2003.581.1		Giardia	See Attached	# / L	1	0	S	09-12-03	09-12-03

Sample: *#37 RIO GRANDE RIVER* Collected: *09-11-03 9:50:00* By: *JS*
Matrix: G

QC Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
0309259-02A		EPA 180.1 Turbidity, Nephelometric					By:	ML		
TU0348	WC.2003.2266.2		Turbidity	2590	NTU	1	0.3		09-12-03	09-12-03

Unless otherwise noted, all samples were received in acceptable condition and all sampling was performed by client or client representative. Sample result of ND indicates Not Detected, ie result is less than the sample specific Detection Limit. Sample specific Detection Limit is determined by multiplying the sample Dilution Factor by the listed Reporting Detection Limit. All results relate only to the items tested. Any miscellaneous workorder information or foonotes will appear below.

MEMO: Subcontracted to CH Diagnostic and Consulting Service, Inc.

2590

 SQLCoyote: Reports *1.0.0307301320XX* *Report Date* *10/2/2003 9:36:43 AM*

ANALYSIS FOR WATERBORNE PARTICULATES

Invoice 20030748

CH Diagnostic and Consulting Service, Inc.
214 SE 19th Street, Loveland, CO 80537
Brec L. Clay, President/Treasurer; Gregory D. Sturbaum, President/Secretary
(970) 667-9789

Customer 950726
Assaigai Analytical Labs
4301 Masthead N.E.
Albuquerque, NM 87109

Laboratory Information
UPS; 9/12/03; 0955 Hrs; 3°C; Carboy- 4-1L
Results submitted by:
Brec L. Clay President/Treasurer

Sample Identification: City of Santa Fe, Rio Grande River, #36, Raw water

Sample Information: SOURCE: Stream or River

Sample Date & Time: 9/11/03 09:50 AM OK Sampler: unrec.

Amount: 2.4 L Filter Color: N/A Filter Type: Envirochek™ HV capsule

Date/Time Eluted: 9/12/03 10:43 AM Centrifugate: 500 mL/100 L

RESULTS OF 1623 GIARDIA AND CRYPTOSPORIDIUM ANALYSIS

Amount of sample assayed: 0.0984 L

		Total IFA Count	Empty	Amorphous Structure	1 Internal Structure	>=2 Internal Structure	Internal Structure	DAPI+ (nuclei stained)	DAPI+ (intense internal staining)	DAPI-
Giardia	detected	1	0	1	0	0		0	0	1
	# / L	10	<10	10	<10	<10		<10	<10	10
Cryptosporidium	detected	0	0	0			0	0	0	0
	# / L	<10	<10	<10			<10	<10	<10	<10

This sample was analyzed for *Giardia* and *Cryptosporidium* by the method outlined in: Method 1623: *Cryptosporidium* and *Giardia* in Water by Filtration/IMS/FA. April 2001 USEPA, Washington D.C., EPA-821-R-01-025. All limitations stated in the method apply. Detection limit calculated from volume assayed. If HV capsule or foam filter was received, method was modified by filtering sample through a Pall Envirochek™ HV capsule or IDEXX Filta-Max™ filter at the sample site. If Microscopic Particulate Analysis was also performed, particulate extraction was modified.

packed pellet = 5 mL

ASSAIGAI ANALYTICAL LABORATORIES, INC.

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127 Eastgate Drive, 212-C • Los Alamos, New Mexico 87544 • (505) 662-2558

Explanation of codes	
B	analyte detected in Method Blank
E	result is estimated
H	analyzed out of hold time
N	tentatively identified compound
S	subcontracted
1-9	see footnote

CITY OF SANTA FE
attn: GARY MARTINEZ
1780 CANYON RD.
SANTA FE NM 87501

STANDARD

Assaigai Analytical Laboratories, Inc.

Certificate of Analysis

Client: CITY OF SANTA FE
Project: RIO GRANDE RIVER
Order: 0310185 SANC9 Receipt: 10-09-03

William P. Biava: President of Assaigai Analytical Laboratories, Inc.

Sample: *#58 RIO GRANDE RIVER* Collected: *10-09-03 10:00:00* By: *JS*
Matrix: *G*

QC Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
0310185-01A		METHOD 1623					By:	CHD		
CHD20030831	SB.2003.660.1		Cryptosporidium	See Attached	# / L	1	0	S	10-10-03	10-10-03
CHD20030831	SB.2003.660.1		Giardia	See Attached	# / L	1	0	S	10-10-03	10-10-03

Sample: *#59 RIO GRANDE RIVER* Collected: *10-09-03 10:00:00* By: *JS*
Matrix: *G*

QC Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
0310185-02A		EPA 180.1 Turbidity, Nephelometric					By:	MML		
TU0357	WC.2003.2538.2		Turbidity	71.2	NTU	1	0.3		10-10-03	10-10-03

Unless otherwise noted all samples were received in acceptable condition and all sampling was performed by client or client representative. Sample result of ND indicates Not Detected, ie result is less than the sample specific Detection Limit. Sample specific Detection Limit is determined by multiplying the sample Dilution Factor by the listed Reporting Detection Limit. All results relate only to the items tested. Any miscellaneous workorder information or footnotes will appear below.

MEMO Subcontracted to CH Diagnostic and Consulting Service, Inc.

ACCREDITED

ANALYSIS FOR WATERBORNE PARTICULATES

Invoice 20030831

CH Diagnostic and Consulting Service, Inc.
214 SE 19th Street, Loveland, CO 80537
Brec L. Clay, President/Treasurer; Gregory D. Sturbaum, President/Secretary
(970) 667-9789

Customer 960726
Accaigai Analytical Labs
4301 Masthead N.E.
Albuquerque, NM 87109

Laboratory Information
UPS; 10/10/03; 0900 Hrs; 5°C; carboy 4-4L
Results submitted by:
Brec L Clay President/Treasurer

Sample Identification: #58, Rio Grande River, 0310185-01A, Raw water

Sample Information: SOURCE: Stream or River

Sample Date & Time: 10/9/03 10:00 AM Sampler: unrec.

Amount: 10 L Filter Color: N/A Filter Type: Envirochek™ HV capsule

Date/Time Eluted: 10/10/03 01:58 PM Centrifugate: 25 mL/100 L

[illegible]

Amount of sample assayed: 2 L

		Total IFA Count	Empty	Amorphous Structure	1 Internal Structure	>=2 Internal Structure	Internal Structure	DAPI+ (nuclei stained)	DAPI+ (Intense internal staining)	DAPI-
Giardia	detected	24	0	14.4	9.6	0		9.6	2.4	12
	# / L	10	<0.5	7	5	<0.5		5	1	6
Cryptosporidium	detected	0	0	0			0	0	0	0
	# / L	<0.5	<0.5	<0.5			<0.5	<0.5	<0.5	<0.5

This sample was analyzed for *Giardia* and *Cryptosporidium* by the method outlined in: Method 1623: *Cryptosporidium* and *Giardia* in Water by Filtration/IMS/FA. April 2001 USEPA, Washington D.C., EPA-821-R-01-025. All limitations stated in the method apply. Detection limit calculated from volume assayed. If HV capsule or foam filter was received, method was modified by filtering sample through a Pall Envirochek™ HV capsule or IDEXX Filta-Max™ filter at the sample site. If Microscopic Particulate Analysis was also performed, particulate extraction was modified.

12

packed pellet = 0.25 mL

ASSAIGAI ANALYTICAL LABORATORIES, INC.

4301 Masthead NE • Albuquerque, New Mexico 87109 • (505) 345-8964 • FAX (505) 345-7259
3332 Wedgewood, Ste. N • El Paso, Texas 79925 • (915) 593-6000 • FAX (915) 593-7820
127 Eastgate Drive, 212-C • Los Alamos, New Mexico 87544 • (505) 662-2558

Explanation of codes

B	analyte detected in Method Blank
E	result is estimated
H	analyzed out of hold time
N	tentatively identified compound
S	subcontracted
1-9	see footnote

CITY OF SANTA FE
attn GARY MARTINEZ
1780 CANYON RD.
SANTA FE NM 87501

STANDARD

Assaigai Analytical Laboratories, Inc.

Certificate of Analysis

Client: CITY OF SANTA FE
Project: RIO GRANDE RIVER
Order: 0311097 SANC9 Receipt: 11-06-03

William P. Biava: President of Assaigai Analytical Laboratories, Inc.

Sample: *#76 RIO GRANDE RIVER* Collected: 11-06-03 9:30:00 By: JS
Matrix: G

QC Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
0311097-01A		EPA 1623						By: CHD		
CHD20030904	SB.2003.710.1		Cryptosporidium	See Attached	# / L	1	0	S	11-07-03	11-07-03
CHD20030904	SB.2003.710.1		Giardia	See Attached	# / L	1	0	S	11-07-03	11-07-03

Sample: *#77 RIO GRANDE RIVER* Collected: 11-06-03 9:30:00 By: JS
Matrix: G

QC Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
0311097-02A		EPA 180.1 Turbidity, Nephelometric						By: MML		
TU03063	WC.2003.2763.2		Turbidity	16.1	NTU	1	0.3		11-07-03	11-07-03

Unless otherwise noted, all samples were received in acceptable condition and all sampling was performed by client or client representative. Sample result of ND indicates Not Detected, ie result is less than the sample specific Detection Limit. Sample specific Detection Limit is determined by multiplying the sample Dilution Factor by the listed Reporting Detection Limit. All results relate only to the items tested. Any miscellaneous workorder information or foonotes will appear below.

MEMO: Subcontracted to CH Diagnostic and Consulting Service, Inc.

16.1

ANALYSIS FOR WATERBORNE PARTICULATES

Invoice 20030904

CH Diagnostic and Consulting Service, Inc.
214 SE 19th Street, Loveland, CO 80537
Brec L. Clay, President/Treasurer; Gregory D. Sturbaum, President/Secretary
(970) 667-9789

Laboratory Information

UPS; 11/7/03; 0740 Hrs; 2°C; carboy- 4(1gallon)
Results submitted by:
Brec L Clay, President/Treasurer

Customer 960726
Assaigai Analytical Labs
4301 Masthead N.E.
Albuquerque, NM 87109

Sample Identification: Rio Grande River, 0311097-01A, Raw water

Sample Information:

Sample Date & Time: 11/6/03 09:30 AM **Sampler:** unrec.

Amount: 11 L **Filter Color:** N/A **Filter Type:** Envirochek™ HV capsule

Date/Time Eluted: 11/7/03 09:18 AM **Centrifugate:** 8.18 mL/100 L

Amount of sample assayed: 6.116 L

		Total IFA Count	Empty	Amorphous Structure	1 Internal Structure	>=2 Internal Structure	Internal Structure	DAPI+ (nuclei stained)	DAPI+ (intense internal staining)	DAPI-
Giardia	detected	68	0	40.8	20.4	6.8		6.8	0	61.2
	# / L	10	<0.2	7	3	1		1	<0.2	10
Cryptosporidium	detected	1	0	1			0	1	0	0
	# / L	0.2	<0.2	0.2			<0.2	0.2	<0.2	<0.2

This sample was analyzed for *Giardia* and *Cryptosporidium* by the method outlined in: Method 1623: *Cryptosporidium* and *Giardia* in Water by Filtration/IMS/FA. April 2001. USEPA, Washington D.C., EPA-821-R-01-025. All limitations stated in the method apply. Detection limit calculated from volume assayed. If HV capsule or foam filter was received, method was modified by filtering sample through a Pall Envirochek™ HV capsule or IDEXX Filta-Max™ filter at the sample site. If Microscopic Particulate Analysis was also performed, particulate extraction was modified.

11

packed pellet - 0.08 mL

ASSAIGAI ANALYTICAL LABORATORIES, INC.
4301 Masthead NE • Albuquerque, New Mexico 87109 • (505) 345-8964 • FAX (505) 345-7259
3332 Wedgewood, Ste. N • El Paso, Texas 79925 • (915) 593-6000 • FAX (915) 593-7820
127 Eastgate Drive, 212-C • Los Alamos, New Mexico 87544 • (505) 662-2558

Explanation of codes

B	analyte detected in Method Blank
E	result is estimated
H	analyzed out of hold time
N	tentatively identified compound
S	subcontracted
1-9	see footnote

CITY OF SANTA FE
attn: GARY MARTINEZ
1780 CANYON RD.
SANTA FE NM 87501

STANDARD

Assaigai Analytical Laboratories, Inc.

Certificate of Analysis

Client: CITY OF SANTA FE
Project: RIO GRANDE RIVER
Order: 0312143 SANC9 Receipt: 12-04-03

William P. Biave: President of Assaigai Analytical Laboratories, Inc.

Sample: *#80 RIO GRANDE RIVER* Collected: *12-04-03 9:10:00* By: *JS*
Matrix: *G*

QC Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
0312143-01A		METHOD 1623					By:	CHD		
CHD20030972	SB.2003.748.1		Cryptosporidium	See Attached	# / L	1	0	S	12-05-03	12-05-03
CHD20030972	SB.2003.748.1		Giardia	See Attached	# / L	1	0	S	12-05-03	12-05-03

Sample: *#81 RIO GRANDE RIVER* Collected: *12-04-03 9:10:00* By: *JS*
Matrix: *G*

QC Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
0312143-02A		EPA 180.1 Turbidity, Nephelometric					By:	BAS		
TU03070	WC.2003.3009.2		Turbidity	25.3	NTU	1	0.3		12-05-03	12-05-03

Unless otherwise noted, all samples were received in acceptable condition and all sampling was performed by client or client representative. Sample result of ND indicates Not Detected, ie result is less than the sample specific Detection Limit. Sample specific Detection Limit is determined by multiplying the sample Dilution Factor by the listed Reporting Detection Limit. All results relate only to the items tested. Any miscellaneous workorder information or foonotes will appear below.

MEMO: Subcontracted to CH Diagnostic and Consulting Service, Inc.

ANALYSIS FOR WATERBORNE PARTICULATES

Invoice 20030972

CH Diagnostic and Consulting Service, Inc.
214 SE 19th Street, Loveland, CO 80537
Brec L. Clay, President/Treasurer; Gregory D. Sturbaum, President/Secretary
(970) 667-9789

Customer 950726
Assaigai Analytical Labs
4301 Masthead N.E.
Albuquerque, NM 87109

Laboratory Information

Federal Express; 12/5/2003; 0925 Hrs; 2°C; Carboy-4 (1gal.)
Results submitted by:
Brec L Clay, President/Treasurer

Sample Identification: #80 Rio Grand River, Raw water

Sample Information:

Sample Date & Time: 12/4/2003 09:10 AM OK **Sampler:** unrec.

Amount: 10 L **Filter Color:** N/A **Filter Type:** Envirochek™ HV capsule

Date/Time Eluted: 12/5/2003 01:45 PM **Centrifugate:** 10 mL/100 L

[illegible]

Amount of sample assayed: 5 L

		Total IFA Count	Empty	Amorphous Structure	1 Internal Structure	>=2 Internal Structure	Internal Structure	DAPI+ (nuclei stained)	DAPI+ (Intense Internal staining)	DAPI-
Giardia	detected	19	1.9	11.4	3.8	1.9		3.8	0	15.2
	#/L	4	0.4	2	0.8	0.4		0.8	<0.2	3
Cryptosporidium	detected	0	0	0			0	0	0	0
	#/L	<0.2	<0.2	<0.2			<0.2	<0.2	<0.2	<0.2

This sample was analyzed for *Giardia* and *Cryptosporidium* by the method outlined in: Method 1623: *Cryptosporidium* and *Giardia* in Water by Filtration/IMS/FA. April 2001. USEPA, Washington D.C., EPA-821-R-01-025. All limitations stated in the method apply. Detection limit calculated from volume assayed. If HV capsule or foam filter was received, method was modified by filtering sample through a Pall Envirochek™ HV capsule or IDEXX Filta-Max™ filter at the sample site. If Microscopic Particulate Analysis was also performed, particulate extraction was modified.

packed pellet = 0.16 mL

ASSAIGAI ANALYTICAL LABORATORIES, INC.
4301 Masthead NE • Albuquerque, New Mexico 87109 • (505) 345-8964 • FAX (505) 345-7259
3332 Wedgewood, Ste. N • El Paso, Texas 79925 • (915) 593-6000 • FAX (915) 593-7820
127 Eastgate Drive, 212-C • Los Alamos, New Mexico 87544 • (505) 662-2558

Explanation of codes

B	analyte detected in Method Blank
E	result is estimated
H	analyzed out of hold time
N	tentatively identified compound
S	subcontracted
1-8	see footnote

CITY OF SANTA FE
attn: GARY MARTINEZ
1780 CANYON RD.
SANTA FE NM 87501

STANDARD

Assaigai Analytical Laboratories, Inc.

Certificate of Analysis

Client: CITY OF SANTA FE
Project: RIO GRANDE RIVER
Order: 0401039 SANC9 Receipt: 01-06-04

William P. Pfeifer, President of Assaigai Analytical Laboratories, Inc.

Sample: *#82 RIO GRANDE RIVER* Collected: *01-06-04 9:40:00* By: JS
Matrix: G

QC Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
							By:	CHD		
0401039-01A		METHOD 1623								
CHD20040014	SB.2004.33.1		Cryptosporidium	See Attached	#/L	1	0	S	01-08-04	01-08-04
CHD20040014	SB.2004.33.1		Giardia	See Attached	#/L	1	0	S	01-08-04	01-08-04

Sample: *#83 RIO GRANDE RIVER* Collected: *01-06-04 9:40:00* By: JS
Matrix: G

QC Group	Run Sequence	CAS #	Analyte	Result	Units	Dilution Factor	Detection Limit	Code	Prep Date	Run Date
							By:	BAS		
0401039-02A		EPA 180.1 Turbidity, Nephelometric								
TU041	WC.2004.61.2		Turbidity	7.8	NTU	1	0.3		01-07-04	01-07-04

Unless otherwise noted, all samples were received in acceptable condition and all sampling was performed by client or client representative. Sample result of ND indicates Not Detected, ie result is less than the sample specific Detection Limit. Sample specific Detection Limit is determined by multiplying the sample Dilution Factor by the listed Reporting Detection Limit. All results relate only to the items tested. Any miscellaneous workorder information or footnotes will appear below.

MEMO Subcontracted to CH Diagnostic and Consulting Service, Inc.

 SQLCoyote: Reports 1.0.0310221500XX Report Date 1/20/2004 4:11:05 PM

ANALYSIS FOR WATERBORNE PARTICULATES

Invoice 20040014

CH Diagnostic and Consulting Service, Inc.
214 SE 18th Street, Loveland, CO 80537
Brec L. Clay, President/Treasurer; Gregory D. Sturbaum, President/Secretary
(970) 667-9789

Laboratory Information
UPS; 1/7/2004; 1000 Hrs; 1°C; 4-1gal carboys
Results submitted by:
President/Treasurer

Customer 960728
Assaigai Analytical Labs
4301 Masthead N.E.
Albuquerque, NM 87109

Sample Identification: 0401038-01A, SANC9-#82 RIO GRANDE RIVER, Raw water

Sample Information: Sampler: unrec.

Sample Date & Time: 1/6/2004 09:40 AM Filter Type: Envirochek™ HV capsule

Filter Color: N/A

Amount: 10 L Centrifugate: 3 mL/100 L

Date/Time Eluted: 1/8/2004 08:50 AM

RESULTS OF 1623 GIARDIA AND CRYPTOSPORIDIUM ANALYSIS

Amount of sample assayed: 10 L

		Total IFA Count	Empty	Amorphous Structure	1 Internal Structure	>=2 Internal Structure	Internal Structure	DAPI+ (nuclei stained)	DAPI+ (intense internal staining)	DAPI-
Giardia	detected	23	0	13.8	6.9	2.3		6.9	2.3	13.8
	# / L	2	<0.1	1	0.7	0.2		0.7	0.2	1
Cryptosporidium	detected	0	0	0			0	0	0	0
	# / L	<0.1	<0.1	<0.1			<0.1	<0.1	<0.1	<0.1

This sample was analyzed for *Giardia* and *Cryptosporidium* by the method outlined in: Method 1623: *Cryptosporidium* and *Giardia* in Water by Filtration/IMS/FA. April 2001 USEPA, Washington D.C., EPA-821-R-01-025. All limitations stated in the method apply. Detection limit calculated from volume assayed. If HV capsule or foam filter was received, method was modified by filtering sample through a Pall Envirochek™ HV capsule or IDEXX Filta-Max™ filter at the sample site. If Microscopic Particulate Analysis was also performed, particulate extraction was modified.

APPENDIX C
TASTE AND ODOR EVALUATION TECHNICAL MEMORANDUM

Technical Memorandum

MRC WTP Water Quality Studies and Evaluations Project Taste and Odor Evaluation

March 18, 2005

Summary

Purpose

The purpose of this memorandum is to summarize the potential for taste and odor problems for the Buckman Direct Diversion Project based upon raw water quality testing over three seasons.

Conclusions

Data collected during the three rounds of testing were within historical water quality ranges for the Rio Grande near the proposed diversion location. The results of the testing show that odor constituents were not present during the three rounds of testing and may only be an occasional concern. Taste constituents were present in all three rounds of testing and iron, manganese, and sodium are the most likely constituents to be present at levels that could cause taste complaints if concentrations are not reduced through treatment. Likewise, natural occurring organic matter (NOM) and organic contaminants (herbicides, pesticides, etc.) may potentially contribute to taste complaints.

Background

Taste and odor are aesthetic qualities of drinking water that are most often measured by human perception and result in customer complaints. Although all water sources can have undesirable taste and odor causing substances present, surface water sources are more likely to be affected. The water for the Buckman Direct Diversion is a river source that is stored in upstream reservoirs. Storage in a reservoir creates the potential for algal blooms and runoff contamination, as well as vulnerability concerns.

Inorganic compounds are one source of unwanted tastes in drinking water. Specifically, ferrous (Fe^{2+}) and manganese (Mn^{2+}) ions can be present in surface water due to mixing and pH changes that thermal stratification and oxygen depletion cause. This most often occurs within reservoirs. These ions can produce metallic tastes if present at high enough concentrations. Copper and zinc also can cause the water to have a metallic taste. High sodium, hardness, total dissolved solids and alkalinity are other common causes of customer taste complaints. However, the most common taste problems are caused by the use of chlorine as a disinfectant; chlorine has an extremely distinctive taste.

Another source of taste and odors in water supplies is the growth and decay of microorganisms in surface water. Two compounds, 2-methylisoborneol (MIB) and geosmin, are most commonly cited as imparting unpleasant earthy/musty tastes and odors to waters. The source of these and other compounds associated with taste and odor is primarily the degradation products of blue-green algae (cyanobacteria) and certain fungi (actinomycetes). These taste and odor causing problems are more likely with surface water sources impounded in reservoirs where algal blooms can occur. Table 1 presents a summary of the taste and odors problems, the chemical or biological cause, and the applicable measurement level where problems are first discernable.

Table 1. Summary of Taste and Odor Causing Compounds

Smell or Taste	Cause	Minimum Level to Cause Complaints, or MCL if lower[1]
Taste Problems		
Salty Brackish	high sodium	20 mg/L
Alkali	high hardness total dissolved solids high alkalinity	80 mg/L 500 mg/L <30 or >300 mg/L[2]
Metallic	iron manganese copper zinc	0.04-0.1 mg/L 0.05 mg/L 1 mg/L 4-5 mg/L
Organics	naturally occurring matter or organic contaminants (i.e. algal bio-products, herbicides, pesticides)	0-10 mg/L (varies according to constituent)
Odor Problems		
Rotten-Egg	hydrogen sulfide	0.0001 mg/L
Musty, earthy, or fishy	algal (blue-green and fungal) bio-products - geosmin - MIB - 2-Isobutyl-3-methoxy pyrazine (IBMP) - Isopropyl methoxy pyrazine (IPMP) - 2,4,6-Trichloroanisole (2,4,6-TCA) algal (flagellates and diatoms) bio-products	 <5-10 ng/L <5-10 ng/L <5-10 ng/L <5-10 ng/L <5-10 ng/L

[1]Sources:

American Water Works Assoc./ American Society of Civil Engineers *Water Treatment Plant Design (3rd Ed.)* (1998).

Integrated *Design and Operation of Water Treatment Facilities (2nd Ed.)* by Susumu Kawamura (2000).

United States Environmental Protection Agency *List of Drinking Water Contaminants & MCLs.*

Water Quality Assoc. *List of National Secondary Drinking Water Standards and Other Aesthetic Contaminants.*

[2]Low alkalinity waters tend to dissolve minerals and metals, high alkalinity waters tend to precipitate minerals and metals (thus effecting taste).

The odor causing algal bio-products can be measured in the laboratory with gas chromatography - mass spectrometry methodologies. Other constituents such as iron, copper, hardness, etc. are also easily measured with standard laboratory techniques. Detection and measurement methodologies for overall odors are not well developed.

Threshold Odor Number (TON) is a measure of the water's odor intensity. TON is derived by specific dilutions of odor free water with the water being tested and is diluted until nearly no odor is perceived. A TON of 1.4 would be 140 milliliters (mls) of sample water with 60 mls of odor free water and just being able to detect an odor. A TON of 2 would be 100 mls of both sample water and odor free water. A TON of 1 is undiluted (200 mls of sample water) and essentially odor free. Determination of the amount of odor is typically done by a panel of odor testers using EPA Test Method 0140.1 (Odor Threshold). Because of the inherent inaccuracies of individuals, the TON is not an absolute measurement. However, a TON of 3 has been set as a secondary (unenforceable) drinking water standard.

Laboratory Results

Sampling and laboratory analyses were conducted during all three rounds of testing of the project: spring run-off, summer monsoon, and fall low flow periods. The raw water utilized for sampling was collected from the proposed location of the Buckman Direct Diversion Project Intake Structure on the Rio Grande. Spring run-off water was sampled on May 21, 2003. Flow in the Rio Grande, as measured at the Otowi gaging station was approximately 1,100 cubic feet per second (cfs). Summer monsoon testing was completed on August 8, 2003. Flow in the Rio Grande was 1,030 cfs. Fall low flow testing was completed on October 28, 2003. According to the Otowi gage, the flow in the Rio Grande was 385 cfs. Table 2 presents the results of the laboratory analyses of the selected compounds.

Table 2. Laboratory Results for Rio Grande Samples

Compound	Threshold Level	Testing Period		
		Spring Run-Off (5/21/03)	Summer Monsoon (8/8/03)	Fall Low Flow (10/28/03)
Taste Causing Components				
Iron	0.04-0.1 mg/L	0.03 mg/L	2.2 mg/L	0.64 mg/L
Manganese	0.05 mg/L	0.015 mg/L	0.057 mg/L	0.030 mg/L
Copper	1 mg/L	0.0014 mg/L	0.0039 mg/L	0.0039 mg/L
Sodium	20 mg/L	17 mg/L	13 mg/L	24 mg/L
Total Alkalinity	<30-300 mg/L	100 mg/L	69 mg/L	130 mg/L
Total Dissolved Solids	500 mg/L	190 mg/L	220 mg/L	260 mg/L
Total Hardness as CaCO3	80 mg/L	130 mg/L	120 mg/L	140 mg/L
Odor Causing Components				
Threshold Odor Number (TON)	3	<1.0	<1.0	<1.0
Geosmin	<5-10 ng/L	<5 ng/L	NM	NM
MIB	<5-10 ng/L	<5 ng/L	NM	NM
2-Isobutyl-3-methoxy pyrazine (IBMP)	<5-10 ng/L	<5 ng/L	NM	NM
Isopropyl methoxy pyrazine (IPMP)	<5-10 ng/L	<5 ng/L	NM	NM
2,4,6-Trichloroanisole (2,4,6-TCA)	<5-10 ng/L	<5 ng/L	NM	NM

NM = Not measured

Discussion of Results

The testing results indicate that taste causing components are present in the raw water but that odor causing components are not.

During the first round of testing (spring run-off), most of the inorganic taste causing constituents were at their lowest concentration seen throughout the testing and at concentrations lower than normally detectable by water customers. The concentrations of all of these components were dramatically higher in both of the other two testing rounds (summer monsoon and fall low flow) when rain and lower reservoir and river flows contribute to an increasing concentration of soil and organic material loading to the river.

Manganese was present at a discernable concentration only during the second testing period. The concentration of total dissolved solids and copper were below the taste threshold (and secondary standards) in all testing periods. Iron was elevated above the taste threshold in both the second and third testing periods. Sodium was elevated only during the third round.

Total hardness was higher than the minimum level for taste complaints during all periods. However, the level shown in Table 1 (80 mg/L) is a concentration were complaints are more common when customers are used to soft water produced by a water softening treatment plant. The customers in Santa Fe (and in the west) are accustomed to harder water. The water tested is softer than that of the Buckman Wells water which ranges from 19 to 506 mg/L in the 13 wells. Three of the existing wells have a hardness greater than 250 mg/L and two of these are over 500 mg/L. Historically, the City's Water Division receives more complaints when the Buckman Wells are providing a larger percentage of the City's water than is the Canyon Road Water Treatment Plant. Therefore, the hardness of the Rio Grande source water is not expected to cause complaints. Likewise, the alkalinity of the Buckman wells is considerably higher than the raw river water. The range of alkalinity in the Buckman Wells is 124 to 763 mg/L and the composite of the wells is often higher than the 300 mg/L threshold concentration. Therefore, the alkalinity in the Rio Grande water is not likely to be a source of complaints.

The United States Geological Survey (USGS) has completed extensive water quality testing of the Rio Grande at the Otowi gaging station over the past 44 years. The Otowi gaging station is located just a few miles upstream of the proposed diversion location and therefore the data is a great indicator of the water quality that will be diverted for the project. This data was reviewed to determine a historical range and average of the taste causing components (no odor causing components are included in the historical data). Table 3 presents the range and historical average for the taste causing constituents.

Table 3. Rio Grande Water Quality Data from USGS Otowi Gaging Station

Parameter	Threshold Values	Historical Range, mg/L	Historical Average, mg/L
Dissolved Iron	0.04-0.1 mg/L	<0.001 – 13	0.057
Dissolved Manganese	0.05 mg/L	<0.001 – 0.180	0.010
Dissolved Copper	1 mg/L	<0.001 – 0.035	0.0035
Dissolved Sodium	20 mg/L	7.5 – 63	23.1
Dissolved Zinc	4-5 mg/L	<0.001 – 0.0071	0.010
Alkalinity	<30-300 mg/L	62 - 150	100
Total Dissolved Solids	500 mg/L	117 - 1,030	251
Total Hardness[1]	80 mg/L	66 - 148	143

[1]Calculated from calcium and magnesium concentrations

The results obtained during the three rounds of testing are all within the historical range of Otowi gaging station data. Zinc was not analyzed during the three testing periods. However, the Otowi Gaging station data show the concentration has never been higher than 71 ug/L, far less than the 4 mg/L taste threshold and thus not likely to cause a taste problem.

The odor causing algal bio-products were non-detect during the first round of sampling. The non-detect result was confirmed by a laboratory TON panel test which was less than 1.0 for all periods. As explained above, a TON of less than 1.0 indicates that the raw water did not have a discernable odor even when undiluted. No analyses for algal bio-products were conducted in the second or third round. However, the TON was non-detect in these rounds. Although the TON and algal bio-products testing indicated the water did not have a discernable odor, a musty odor was slightly detectable during handling of the water for the bench scale testing. However, the odor was not discernable in the treated water.

Although algae does not appear to be a pervasive problem in the raw river water, it may become an issue if lagoons are used near the river for pre-sedimentation. The lagoons would be designed to remove sand and grit particles to protect mechanical equipment. There is a possibility that algae will grow in the lagoons at certain times of the year. Therefore, design and operation of the lagoons must consider prevention and mitigation (through chemical or nutrient control) of algae.

APPENDIX D
CONTAMINANTS STUDY TECHNICAL MEMORANDUM

CDM

Technical Memorandum

MRC WTP Water Quality Studies and Evaluations Project Contaminants Study

March 18, 2005

Summary

Purpose

This memorandum presents the results of analytical sampling conducted to determine the presence and concentration of contaminants in the raw water source for the Buckman Direct Diversion Project. The concentration of contaminants was also studied in a number of the existing Buckman wells.

Conclusions

The analyses and historic data indicate that only a few constituents are present above drinking water standards in the raw water at Buckman. The constituents include turbidity, color, aluminum, iron, manganese, and nitrate. Treatment and/or removal of these constituents need to be the goal of the new MRC WTP.

The data collected for the Buckman wells indicate that two main contaminants are present that may pose a regulatory compliance problem, arsenic and uranium. Data were collected from nine of the thirteen wells and of those wells, five exceed the arsenic MCL of 10 μg/L. Well 2 was the only well of the nine where uranium approaches or exceeds the proposed MCL.

Background

Drinking water standards are regulations that EPA sets to control or minimize the level of contaminants in the nation's drinking water. These standards are part of the Safe Drinking Water Act's "multiple barrier" approach to drinking water protection, which includes assessing and protecting drinking water sources; protecting wells and collection systems; requiring water to be treated by qualified operators; providing for the integrity of distribution systems; and making information available to the public on the quality of their drinking water. These standards were developed under the provisions of the Safe Drinking Water Act and the subsequent 1986 and 1996 amendments.

There are two categories of drinking water standards:

- A National Primary Drinking Water Regulation (NPDWR or primary standard) is a legally enforceable standard that applies to public water systems. Primary standards protect drinking water quality by limiting the levels of specific contaminants that can adversely affect public health and are known or anticipated to occur in water. They take the form of MCLs or Treatment Techniques. Currently, there are primary standard for over 90 contaminants. The primary standards include microbes, radionuclides, inorganics, volatile organics, synthetic organics, disinfectants, disinfection byproducts, and MTBE.

- A National Secondary Drinking Water Regulation (NSDWR or secondary standard) is a non-enforceable guideline regarding contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt these as enforceable standards. New Mexico does not enforce secondary standards. Approximately 15 contaminants are on the EPA secondary standards list.

Many of the primary standards are discussed in other related CDM technical memoranda. These include disinfectants and disinfection byproducts and microbes. The laboratory results and evaluation presented in this memorandum include the radionuclides, inorganics, volatile organics, and synthetic organics. A few of the secondary standards are discussed in this document. Refer to the *Regulatory Requirements Review and Evaluation Technical Memorandum* for additional information on the specific regulations.

A review of the source water quality for specific contaminants regulated with drinking water standards is important because high levels of regulated contaminants may require the construction of specific unit processes capable of removing the contaminant.

Laboratory Results

Sampling and laboratory analysis were conducted to determine the levels of synthetic organic contaminants, nitrates, selected metals, arsenic and radionuclides that may be present in the Rio Grande water during three testing periods. Sampling and laboratory analyses were conducted during all three testing phases of the project: spring run-off, summer monsoon, and fall low flow periods. Spring run-off water was sampled on May 21, 2003. Flow in the Rio Grande, as measured at the Otowi was approximately 1,100 cubic feet per second (cfs). Summer monsoon testing was completed on August 8, 2003. Flow in the Rio Grande was 1,030 cfs. Fall low flow testing was completed on October 28, 2003. According to the Otowi Gage, the flow in the Rio Grande was 385 cfs. Additionally, four Buckman groundwater wells and Booster Station 3 were tested for these contaminants during one period on October 28, 2003. The results of the laboratory samples taken from the five newer Buckman wells (9 through 13) after initial pumping are also presented**.** Table 1 presents the laboratory results of the contaminant sampling of the Rio Grande for the three testing periods and the associated MCL. Table 2 shows the contaminant data from the Buckman well and booster station sampling.

Table 1. Laboratory Results for Rio Grande Samples

Contaminant	EPA MCL	Laboratory Results[1]		
		Spring Run-Off (5/21/03)	Summer Monsoon (8/8/03)	Fall Low Flow (10/28/03)
Radionuclides				
Uranium	30 µg/L[2]	2.57 µg/L	1.31 µg/L	3.61 µg/L
Radium-226	MCL for combined only	0.184 pCi/L	0.866 pCi/L	0.054 pCi/L
Radium-228	MCL for combined only	0.926 pCi/L	0.770 pCi/L	1.06 pCi/L
Combined Radium (226 and 228)	5pCi/L	1.11 pCi/L	1.64 pCi/L	1.11 pCi/L
Gross Alpha	15 pCi/L	5.22 pCi/L	3.18 pCi/L	4.18 pCi/L
Gross Beta	[2]	7.14 pCi/L	3.91 pCi/L	5.17 pCi/L
Inorganics				
Arsenic	10 µg/L[3]	<2.0 µg/L	<2.5 µg/L	<2.5 µg/L
Fluoride	4 mg/L	0.4 mg/L	NM	NM
Lead	15 µg/L[4]	<1.0 µg/L	1.8 µg/L	<1.2 µg/L
Nitrate	10 mg/L	<0.1 mg/L	9.4 mg/L	<0.1 mg/L
Nitrite	1 mg/L	0.01 mg/L	<0.01 mg/L	0.01
Keljdahl Nitrogen	NR	NM	NM	< 1.0 mg/L
Other Contaminants				
Turbidity	1 NTU[5]	40 NTU	59 NTU	25 NTU
Secondary or General Water Quality Parameters (Unregulated)				
Aluminum	50 – 200 µg/L[6]	20 µg/L	2500 µg/L	930 µg/L
Bromide	NR	0.03 mg/L	NM	NM
Chloride	250 mg/L[6]	6.3 mg/L	3.5 mg/L	7.4 mg/L
Color	15 pt Co units[6]	20 pt Co units	20 pt Co units	10 pt Co units
Copper	1000 µg/L[6]	1.4 µg/L	3.9 µg/L	3.9 µg/L
Iron	0.3 mg/L[6]	0.03 mg/L	2.2 mg/L	0.64 mg/L
Magnesium	NR	6.3 mg/L	7.4 mg/L	8.3 mg/L
Manganese	50 µg/L[6]	15 µg/L	57 µg/L	30 µg/L
Odor	3 TON[6]	<1.0 TON	<1.0 TON	<1.0 TON
pH	NR	6.5	8.3	8.9
Potassium	NR	2.5 mg/L	3.1 mg/L	3.1 mg/L
Specific Conductance	NR	190 uS/cm	250 uS/cm	240 uS/cm
Sodium	NR	17 mg/L	13 mg/L	24 mg/L
Sulfate	250 mg/L[6]	43 mg/L	47 mg/L	62 mg/L
Suspended Solids	500 mg/L[6]	97 mg/L	38 mg/L	35 mg/L

Table 1. Laboratory Results for Rio Grande Samples

Contaminant	EPA MCL	Laboratory Results[1]		
		Spring Run-Off (5/21/03)	Summer Monsoon (8/8/03)	Fall Low Flow (10/28/03)
Temperature	NR	64 deg F	73 deg F	52 deg F
Total Dissolved Solids (TDS)	500 mg/L[6]	190 mg/L	220 mg/L	260 mg/L
Total Hardness	NR	130 mg/L	120 mg/L	140 mg/L
Synthetic Organics				
Alachlor (Lasso)	2 µg/L	<0.1 µg/L	NM	NM
Aldrin	NR	<0.1 µg/L	NM	NM
Atrazine	3 µg/L	<0.1 µg/L	NM	NM
Benzo(a)pyrene	0.2 µg/L	<0.02 µg/L	NM	NM
Butachlor	NR	<0.1 µg/L	NM	NM
Dieldrin	NR	<0.1 µg/L	NM	NM
Di(2-ethylhexyl)adipate	400 µg/L	<0.6 µg/L	NM	NM
Di(2-ethylhexyl)phthalate	6 µg/L	<0.6 µg/L	NM	NM
Endrin	2 µg/L	<0.01 µg/L	NM	NM
Heptachlor	0.4 µg/L	<0.04 µg/L	NM	NM
Heptachlor epoxide	0.2 µg/L	<0.02 µg/L	NM	NM
Hexachlorobenzene	1 µg/L	<0.1 µg/L	NM	NM
Hexachlorocyclopentadiene	50 µg/L	<0.1 µg/L	NM	NM
Lindane (gamma-BHC)	0.2 µg/L	<0.02 µg/L	NM	NM
Methoxychlor	40 µg/L	<0.1 ug/L	NM	NM
Metolachlor (Dual)	NR	<0.1 µg/L	NM	NM
Metribuzin (Sencor)	NR	<0.1 µg/L	NM	NM
Propachlor	NR	<0.1 µg/L	NM	NM
Simazine	4 µg/L	<0.07 µg/L	NM	NM

[1]Results indicated as <x are the laboratory detection limit of the analysis.

[2]Effective December 2003. Gross Beta regulated as beta and photon emitters with MCL of 4 mrem per year.

[3]Arsenic MCL of 10 µg/L effective January 2006.

[4]An Action Limit (AL) of 15 µg/L has been established for lead.

[5]Filtered water turbidity cannot exceed 1.0 NTU ever with 95% of filtered effluent readings <0.3 NTU as regulated under the Interim Enhanced Surface Water Treatment Rule.

[6]Secondary Maximum Contaminant Level (SMCL).

NOTE - pH, specific conductance, and temperature all measured with field instrument at collection.

NR - not currently regulated.

NM - not measured.

Contaminants approach MCL or other standard.

Contaminants exceed MCL or other standard.

Table 2. Laboratory Results for Buckman Well Samples and Booster Station 3

Contaminant	EPA MCL	Sample Location and Date									
		Well 2 (10/28/03)	Well 6 (10/28/03)	Well 7 (10/28/03)	Well 8 (10/28/03)	Well 9 (4/22/03 or 12/2/02)	Well 10 (9/21/03)[1]	Well 11 (7/19/03)[1]	Well 12 (7/6/03)[1]	Well 13 (9/14/03)[1]	BS 3 (10/28/03)
Radionuclides											
Uranium	30 µg/L[2]	27.9 µg/L	3.98 µg/L	5.77 µg/L	15.6 µg/L	10 µg/L	8 µg/L	<100 µg/L	<100 µg/L	8 µg/L	6.9 µg/L
Radium-226	MCL for combined only	0.257 pCi/L	0.212 pCi/L	0.556 pCi/L	0.327 pCi/L	ND[5]	0.5 pCi/L	<0.2 pCi/L	<0.2 pCi/L	0.2 pCi/L	0.36 pCi/L
Radium-228	MCL for combined only	0.572 pCi/L	1.33 pCi/L	1.25 pCi/L	0.771 pCi/L	ND[5]	<1.0 pCi/L	<1.0 pCi/L	<1.0 pCi/L	<1.0 pCi/L	0.772 pCi/L
Combined Radium (226 and 228)	5pCi/L	0.83 pCi/L	1.54 pCi/L	1.81 pCi/L	1.10 pCi/L	ND[5]	<1.5 pCi/L	<1.2 pCi/L	<1.2 pCi/L	<1.2 pCi/L	1.132 pCi/L
Gross Alpha	15 pCi/L	15.3 pCi/L	4.89 pCi/L	5.34 pCi/L	9.78 pCi/L	1.7 pCi/L[5]	8.9 pCi/L	4.1 pCi/L	4.7 pCi/L	5.7 pCi/L	7.54 pCi/L
Gross Beta	[2]	1.43 pCi/L	2.75 pCi/L	5.89 pCi/L	2.36 pCi/L	ND[5]	7.6 pCi/L	11.8 pCi/L	<2.0 pCi/L	3.9 pCi/L	1.63 pCi/L
Inorganics											
Arsenic	10 µg/L[3]	12 µg/L	4.4 µg/L	3.7 µg/L	7.5 µg/L	16 µg/L	4 µg/L	11 µg/L	18 µg/L	16 µg/L	14 µg/L
Fluoride	4 mg/L	NM	NM	NM	NM	0.72 mg/L	0.61 mg/L	0.92 mg/L	0.54 mg/L	0.47 mg/L	NM
Nitrate	10 mg/L	1.4 mg/L	2.0 mg/L	1.4 mg/L	0.7 mg/L	1.6 mg/L	1.1 mg/L	1.5 mg/L	1.5 mg/L	0.74 mg/L	1.3 mg/L
Nitrite	1 mg/L	<0.01 mg/L	<0.01 mg/L	<0.01 mg/L	<0.01 mg/L	0.14 mg/L	<0.1 mg/L	NM	<0.1 mg/L	<0.1 mg/L	<0.01 mg/L
Secondary or General Water Quality Parameters (unregulated)											
Alkalinity, Total	NR	NM	NM	NM	NM	340 mg/L	260 mg/L	180 mg/L	130 mg/L	140 mg/L	210 mg/L
Aluminum	50 – 200 µg/L[4]	2.7 µg/L	2.0 µg/L	9.9 µg/L	<2.0 µg/L	<20 µg/L	6 µg/L	<20 µg/L	<20 µg/L	14 µg/L	18 µg/L
Calcium	NR	NM	NM	NM	NM	17 mg/L	NM	NM	NM	NM	27 mg/L
Chloride	250 mg/L[4]	NM	NM	NM	NM	8.1 mg/L	7.8 mg/L	5.8 mg/L	4.5 mg/L	5.4 mg/L	4.6 mg/L
Copper	1000 µg/L[4]	NM	NM	NM	NM	<6 µg/L	2 µg/L	<6 µg/L	<6 µg/L	2 µg/L	NM
Iron	0.3 mg/L[4]	0.02 mg/L	0.05 mg/L	<0.02 mg/L	<0.02 mg/L	<0.02 mg/L	0.107 mg/L	0.031 mg/L	<0.005 mg/L	<0.03 mg/L	<0.02 mg/L

Table 2. Laboratory Results for Buckman Well Samples and Booster Station 3

Contaminant	EPA MCL	Sample Location and Date									
		Well 2 (10/28/03)	Well 6 (10/28/03)	Well 7 (10/28/03)	Well 8 (10/28/03)	Well 9 (4/22/03 or 12/2/02)	Well 10 (9/21/03)[1]	Well 11 (7/19/03)[1]	Well 12 (7/6/03)[1]	Well 13 (9/14/03)[1]	BS 3 (10/28/03)
Magnesium	NR	NM	NM	NM	NM	2.0 mg/L	6.4 mg/L	2.4 mg/L	1.1 mg/L	<1 mg/L	NM
Manganese	50 µg/L[4]	<2.0 µg/L	<2.0 µg/L	50 µg/L	<2.0 µg/L	5.7 µg/L	13 µg/L	16 µg/L	9 µg/L	12 µg/L	2.5 µg/L
pH	6-9	8.8	8.8	8.5	8.8	8.14	7.59	7.88	8.21	8.09	7.4
Potassium	NR	NM	NM	NM	NM	3.3 mg/L	4.3 mg/L	2.1 mg/L	1.7 mg/L	1.7 mg/L	NM
Sodium	NR	NM	NM	NM	NM	100 mg/L	72.7 mg/L	68 mg/L	57 mg/L	47.3 mg/L	NM
Specific Conductance	NR	430 uS/cm	320 uS/cm	410 uS/cm	240 uS/cm	640 umhos/cm	480 umhos/cm	380 umhos/cm	280 umhos/cm	300 umhos/cm	390 uS/cm
Sulfate	250 mg/L[4]	NM	NM	NM	NM	29 mg/L	27 mg/L	29 mg/L	26 mg/L	27 mg/L	23 mg/L
Temperature	NR	71 deg F	73 deg F	77 deg F	79 deg F	71 deg F	NM	NM	NM	NM	78 deg F
Total Dissolved Solids (TDS)	500 mg/L[4]	NM	NM	NM	NM	440 mg/L	340 mg/L	270 mg/L	200 mg/L	190 mg/L	290 mg/L
Total Hardness	NR	NM	NM	NM	NM	55.8 mg/L	125 mg/L	68 mg/L	45 mg/L	NM	NM

[1]Analysis based on sampling during initial well testing. Results may vary after a significant duration of pumping.
[2]Effective December 2003. Gross Beta regulated as beta & photon emitters with MCL of 4 mrem per year
[3]Arsenic MCL of 10 µg/L effective January 2006.
[4]Secondary Maximum Contaminant Level (SMCL).
[5]Samples taken on December 2, 2002 that were analyzed for total metals (not dissolved as with other testing).
NR - not currently regulated.
NM - not measured.

Contaminants close to MCL or other standard.
Contaminants exceed MCL or other standard.

Discussion of Results

Rio Grande Surface Water

From Table 1, it can be seen that the following parameters approach or exceed recommended or regulated standards for Buckman Direct Diversion source water: nitrate, turbidity, aluminum, color, iron, and manganese. Comparison of the data with the historical water quality data collected at the Otowi gaging station was completed in an effort to validate the analytical results of the three testing periods. This comparison information is presented in Table 3.

Table 3. Comparison of analytical data with historical range and average Otowi gaging station data

Contaminant	MCL or Secondary Standard	Testing Range	Historical Range at Otowi	Historical Average at Otowi
Nitrate	10 mg/L	<0.1 – 9.4 mg/L	NA	NA
Turbidity	0.3 NTU (95% of samples)	10 – 20 NTU	0.2 – 480 NTU	46.7 NTU
Aluminum	50 – 200 µg/L[1]	20 – 2,500 µg/L	<2 – 1,900 µg/L	46.4 µg/L
Color	15 pt Co units[1]	10 -20 pt Co units	NA	NA
Iron	0.3 mg/L[1]	0.03 – 2.2 mg/L	<0.001 – 13 mg/L	0.057 mg/L
Manganese	50 µg/L[1]	15 – 57 µg/L	<1 – 180 µg/L	10.3 µg/L
Fluoride	4 mg/L	0.4 (one sample only)	<0.1 – 1.3 mg/L	0.4 mg/L
Synthetic Organics	Varies	All below detection limits (one sample only)	All below detection limits	All below detection limits

[1]Secondary standard

There is limited nitrate specific data from the Otowi gaging station and the data that do exist suggest that nitrate levels have always been low (<1 mg/L). Assuming the high nitrate concentration (9.4 mg/L) is not a result of sampling or analytical error, the potential for occasional occurrences of increased nitrate concentrations must be considered. Wastewater treatment plants do operate upstream (two are Los Alamos and Española) of the proposed diversion location. Additionally, farming and cattle grazing occur in the river valley area upstream. Any of these activities may be a source of the nitrate.

The elevated aluminum concentrations seen during the second and third round of testing are high in comparison with the historical average and range. In fact, the 2,500 µg/L measured in the second round is higher than ever recorded at Otowi. The Otowi data suggests that aluminum does increase and peak during the summer months coinciding with the normal monsoon periods. Research also indicates that higher aluminum concentrations often can be attributed to increased soil loading in the water throughout the western United States. This same phenomenon may also explain the increased iron and manganese levels as they increase at the same time aluminum increases. These three metals are secondary standards and not enforceable.

Turbidity fluctuates greatly during the year at Buckman and has been measured as high as 480 NTU. The changing turbidity will impact the applied chemical doses and resulting residual quantities at the treatment plant. Color also fluctuates throughout the year.

The synthetic organic compounds (SOCs) were only tested and analyzed during the first round of sampling. None of the 19 constituents were detected. The historical Otowi gaging station data confirm that the SOCs are not a concern in the Rio Grande source water. Therefore, additional testing was not performed during the second and third testing rounds. Similarly, samples for fluoride were not analyzed during the second and third rounds as the existing data confirmed fluoride was not a constituent of concern.

The analyses and historic data indicate that only a few constituents are present above drinking water standards in the raw water at the proposed point of diversion and treatment of these constituents needs to be the goal of the new treatment plant.

Buckman Wells

There are two contaminants of concern in the Buckman Well Field. Arsenic and radionuclides (mainly uranium). The data shown in Table 2 indicate that Wells 2, 9, 11, 12, and 13 all exceed the upcoming lowered arsenic standard of 10 μg/L. It should be noted that the standard is based upon a total arsenic concentration whereas the data shown for each well is based upon the dissolved arsenic concentration so the concentration at each well may actually be higher than shown. Additionally, the data collected for Wells 9 through 13 is based upon samples collected after development of the well and may not be reflective of the actual characteristics of the well after they are in regular use. Regardless, it is likely that at least some of the wells will exceed the MCL for arsenic.

For radionuclides, Well 2 is known to have fluctuating uranium concentrations, most often exceeding the 30 μg/L MCL. During the sampling event for this project, the uranium concentration was slightly less than the MCL (27.0 μg/L). The gross alpha activity of Well 2 also exceeds the MCL. Unfortunately, the uranium concentrations of Wells 11 and 12 are not known as the analytical testing was performed with a detection limit of 100 μg/L, significantly higher than the MCL. Therefore, uranium was noted as a potential issue in these two wells until additional sampling is completed.

The data shown in Table 2 does not include all Buckman wells. However, there is the potential that depending upon the management and operation of the well field, dilution will be sufficient to address the contaminant concentration concerns. A thorough review of the radionuclides concerns at Well 2 is being performed under a separate study.

APPENDIX E
ORGANICS AND TOC EVALUATION TECHNICAL MEMORANDUM

CDM

Technical Memorandum

MRC WTP Water Quality Studies and Evaluations Project Organics and TOC Evaluation

March 18, 2005

Summary

Purpose

The purpose of this study is to evaluate water quality data to determine the requirements for Total Organic Carbon (TOC) removal at the proposed water treatment plant.

Conclusions

Based upon the sampling data and the existing USGS Otowi water quality data, the TOC removal requirements may change monthly and could be as low as 0 percent and as high as 40 percent. Based upon the historical averages (1990 to 2002), the removal requirements will likely average 25 percent in the winter months (December and January) and 35 percent for the rest of the year. Additional information regarding the regulatory requirements can be found in the CDM technical memorandum titled *MRC WTP Water Quality Studies and Evaluation Project Regulatory Requirements Review.*

Background

The Stage 1 Disinfectants/Disinfection By-Products Rule (DBPR) was published by the EPA in December 1998. It lowered the threshold for TOC, established Maximum Contaminant Levels (MCLs) and MCLevel Goals (MCLGs) and for disinfection by-products (DBPs), and set maximum residual disinfectant levels (MRDLs) for disinfectants. The goal of the State 1 DBPR is to protect against health risks associated with certain DBPs. In an effort to control DBPs, additional steps may need to be taken to further reduce the amount of TOC through the use of enhanced coagulation or enhanced softening. The regulation sets a minimum percent of TOC removal based upon the source water TOC content and alkalinity. Systems must meet TOC removal requirements unless they meet any of the exception criteria including an annual source water TOC of less than 2.0 mg/l. Additional information on the Stage 1 DBPR is included in CDM's *Regulatory Requirements Review Technical Memorandum*. Table 1 presents the required removal percentage of TOC based on the source water TOC and alkalinity.

Table 1. TOC Removal Requirements Under the Stage 1 DPBR

Source Water TOC	Source Water Alkalinity (as mg/L CaCO3)		
	0 - 60 mg/L	>60 - 120 mg/L	>120 mg/L
>2.0 - 4.0 mg/L	35 %	25 %	15 %
>4.0 - 8.0 mg/L	45 %	35 %	25 %
>8.0 mg/L	50 %	40 %	30 %

Laboratory analysis of the source water throughout the three different testing periods will be useful in predicting the range in source water TOC and alkalinity and the resulting TOC removal that will be required during plant operation. While measurement of source water TOC and alkalinity is being conducted during this testing, alternate compliance means are also being monitored. Specific Ultraviolet Absorption (SUVA) at 254 nanometers (nm) is an indicator of the humic content of water. It is a calculated parameter obtained by dividing a sample's ultraviolet absorption at a wavelength of 254 nm (UV254) (in m^{-1}) by its concentration of dissolved organic carbon (DOC) (in mg/L). UV254 is the total amount of light, at a frequency of 254 nm absorbed by dissolved and undissolved components within the sample. The SUVA represents the fraction of TOC that is humic and can be readily coagulated, the remaining fraction of TOC left is primarily non-humic (not water soluble) and is not readily coagulated. Under alternative compliance methods for Stage 1 DBPR, source or treated water SUVA of 2.0 L/mg-m or less is in compliance.

Laboratory Results

Sampling and laboratory analyses were conducted during all three testing phases of the project: spring run-off, summer monsoon, and fall low flow periods. Spring run-off water was sampled on May 21, 2003. Flow in the Rio Grande, as measured at the Otowi gage was approximately 1,100 cubic feet per second (cfs). Summer monsoon testing was completed on August 8, 2003. Flow in the Rio Grande was 1,030 cfs. Fall low flow testing was completed on October 28, 2003. According to the Otowi gage, the flow in the Rio Grande was 385 cfs. Table 2 presents the results of the laboratory analyses of the selected compounds.

Table 2. Laboratory Results of Rio Grande Samples

Constituent	Testing Period		
	Spring Run-Off (5/21/03)	Summer Monsoon (8/8/03)	Fall Low Flow (10/28/03)
TOC	5.6 mg/L	3.2 mg/L	2.4 mg/L
Dissolved Organic Carbon (DOC)	3.8 mg/L	3.6 mg/L	2.1 mg/L
Total Alkalinity	100 mg/L	69 mg/L	130 mg/L
UV 254 (unfiltered)	0.124 cm^{-1} 12.4 m^{-1}	0.149 cm^{-1} 14.9 m^{-1}	0.072 cm^{-1} 7.2 m^{-1}
UV 254 (filtered)	NM	0.103 cm^{-1} 10.3 m^{-1}	0.065 cm^{-1} 6.5 m^{-1}
SUVA (unfiltered)	3.3 L/mg-m	4.1 L/mg-m	3.4 L/mg-m
SUVA (filtered)	NC	2.9 L/mg-m	3.1 L/mg-m

NM - Not measured
NC - Not calculated

Bench scale testing of the Rio Grande water was conducted during each of the three testing periods. During the third testing period, settled water from jars where optimized chemical doses were added, was collected for each of the three primary coagulants being tested. The settled water was then filtered through 0.45 micron filter and analyzed for TOC. The TOC results from this testing was considered to be representative of finished water quality and thus useful in confirming if TOC removal requirements were met. During the second round, a TOC sample was collected from settled water with each coagulant. Although this sample was not filtered (as in the third round) the raw water consisted mainly of DOC and therefore filtering probably would not have resulted in a significant TOC reduction. Table 3 presents the TOC concentration for each coagulant and the chemical doses.

Table 3. Settled and Filtered Water TOC Concentrations

Second Round – Raw TOC = 3.2 – 3.6 mg/L			Third Round– Raw TOC = 2.4 mg/L		
Optimum Chemical Doses	Settled Water		Optimum Chemical Doses	Filtered Water	
	Measured TOC	% Removed		Measured TOC	% Removed
Potassium permanganate – 1.0 mg/L Ferric chloride – 23 mg/L Cationic polymer Nalco 8105 – 1.5 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	2.5 mg/L	21.9-30.6	Potassium permanganate – 0.5 mg/L Ferric chloride – 7 mg/L Cationic polymer C-358 – 2.0 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	2.2 mg/L	8.3
Potassium permanganate – 1.0 mg/L Alum – 27 mg/L Cationic polymer C-358 – 1.5 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	2.9 mg/L	9.4-19.4	Potassium permanganate – 0.5 mg/L Ferric chloride – 4 mg/L Cationic polymer C-358 – 2.0 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	2.4 mg/L	0
Potassium permanganate – 1.0 mg/L Polyaluminum Chloride (PAX 18) – 4 mg/L Cationic polymer Nalco 8105 – 0.5 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	2.7 mg/L	15.6-25.0	Potassium permanganate – 0.5 mg/L Alum – 17 mg/L Cationic polymer C-358 – 1.5 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	2.0 mg/L	16.7
			Potassium permanganate – 0.5 mg/L Alum – 14 mg/L Cationic polymer C-358 – 1.5 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	1.9 mg/L	26.3
			Potassium permanganate – 0.65 mg/L Polyaluminum Chloride (PAX 18) – 3 mg/L Cationic polymer C-358 – 1.5 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	1.9 mg/L	26.3

Discussion of Results

Demonstration of compliance for removal of TOC will be based upon quarterly reporting of the average of the monthly removal percentages that are divided by the month's required removal percentage. For example, if alkalinity is 65 mg/L, raw TOC is 4 mg/L and treated water TOC is 2 mg/L the following results are obtained: 50 percent removal achieved; 25 percent removal required (see Table 1); and monthly TOC value is 2.0 (50% removal achieved/25% removal required).

The quarterly average of the three months must be 1.0 or greater to demonstrate compliance. The compliance demonstration methodology is different if an alternative compliance criterion is used, such as SUVA removal.

For this study, the data collected does not allow for calculation of an average TOC removal by quarter. The data collected will be considered as a monthly collection point to determine the range of removal requirements and the ability to comply with the tested chemical doses. Table 4 presents the alkalinity and TOC data, the removal requirements, and removal percentages that were achieved.

Table 4. TOC Removal Requirements and Percentages Achieved from Tested Rio Grande Samples

Parameter	First Round	Second Round	Third Round
Alkalinity	100 mg/L	69 mg/L	130 mg/L
Raw TOC	5.6 mg/L	3.2 – 3.6 mg/L[3])	2.4 mg/L
Treated TOC[1]	NM	2.5 mg/L (23 mg/L ferric chloride)	1.9 mg/L (14 mg/L alum)
Removal % Requirement[2]	35 %	25 %	15 %
Removal % Achieved	NM	21.9 – 30.6 %	20.8 %
Reported Monthly TOC Value (average of 1.0 of greater in compliance)	NM	0.9 – 1.2	1.4

[1]Lowest TOC presented in Table 3 for ferric chloride or alum is shown here.
[2]Refer to Table 1 for removal requirements.
[3]DOC reported higher than TOC but within acceptable error limits. TOC reported as 3.2, DOC was 3.6 mg/L.
NM – Not measured

As seen in Table 4, the DOC concentration was reported higher than the TOC concentration during the second round of testing. While the DOC and TOC values reported during the second round of testing may not be accurate, they are within acceptable laboratory error limits. Depending upon the correct TOC concentration for the second round data, the removal requirements were achieved in both the second and third rounds. Finished water TOC samples were not collected during the first round of testing, the round where raw water quality dictated the highest removal requirements. During the first round, the non-dissolved organic fraction was a significant portion of the TOC, unlike the other two rounds where it was nearly all dissolved. However, the non-dissolved fraction of TOC is easy to remove via coagulation/flocculation and filtration. It is possible that the removal requirements during the first round of testing could be met if a large portion of the non-dissolved TOC is removed in combination with a small percentage of the DOC.

Because SUVA is indicative of how much of the organic material can be coagulated with metal salts (aluminum or iron), it is a good indicator of the ease of TOC removal through conventional coagulation. SUVA and DOC were fairly consistent throughout the three rounds of testing and SUVA ranged from 3.3 to 4.1 L/mg-m. Typically, SUVA values greater than 3.0 to 4.0 indicate that TOC consists of a larger percentage of humic materials and thus easier to coagulate. This may mean the TOC in the Rio Grande can be readily coagulated.

A better prediction of the monthly TOC removal requirement may be made from the water quality data collected from the Otowi Gaging Station, a USGS gaging station located just a few miles upstream of the proposed Buckman diversion location. Water quality samples for a large number of parameters have been collected at this location since 1990. The latest data available is September 2002. The Otowi data for the period of 1990 to 2002 was compiled and statistically analyzed to determine the average TOC and alkalinity concentrations by month. Additionally, the 95% confidence interval was determined for the data and some outliers were removed from the analysis. The remaining range of both TOC and alkalinity was then compiled. Based upon the average and range of both parameters, an average and range of the required removal percentages was computed. Table 5 presents the data.

Table 5. TOC Removal Requirements by Month Based upon Historical Otowi Data

Month	Average TOC mg/L	TOC Range mg/L	Average Alkalinity mg/L	Alkalinity Range mg/L	Average TOC Removal Requirement %	TOC Removal Requirement Range %
Jan	2.8	1.8-4.6	112	100-128	25	0-35
Feb	4.5	2.4-8.9	104	99-109	35	25-40
Mar	5.3	2.6-8.9	99	86-110	35	25-40
Apr	5.3	4.4-6.9	95	74-109	35	35
May	6.8	4.2-9.4	83	67-107	35	35-40
June	5.1	3.8-7.4	83	62-99	35	25-40
July	5.5	3.6-7.3	100	93-104	35	25-35
Aug	5.4	1.1-9.6	97	75-123	35	0-40
Sept	5.2	3.3-9.4	104	86-122	35	15-40
Oct	4.7	2.4-4.7	108	95-118	35	25-35
Nov	4.6	3.3-7.2	118	100-139	35	15-35
Dec	3.0	2.1-3.8	115	108-120	25	25

Based upon the historical Otowi data shown in Table 5, the average removal requirements will be 25 percent in the winter (December and January) and will be 35 percent for the rest of the year. However, the removal requirements could be as high as 40 percent during February through September. Alternately, the removal requirements could be significantly lower (0 to 15 percent) in some months as shown in the Table, which was the case during the third round of testing. The removal requirements throughout the year and the average TOC and alkalinity concentrations are graphically depicted in Figure 1.

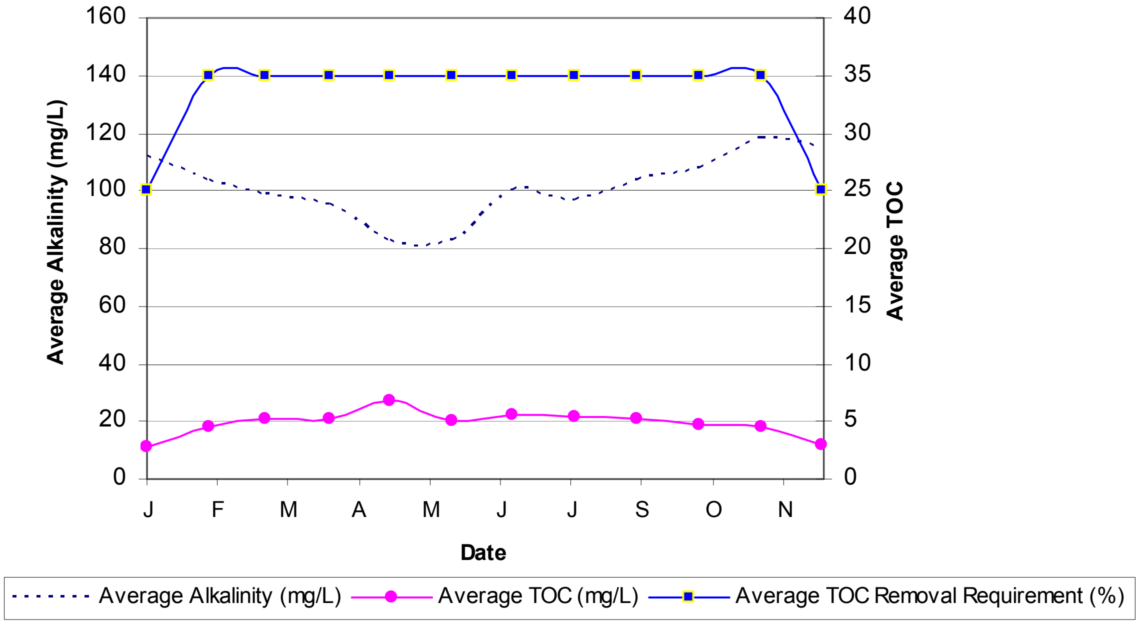


Figure 1. Average TOC Removal Requirements by Month Based upon 1990-2002 USGS Otowi Water Quality Data

APPENDIX F
CHEMICAL DOSE OPTIMIZATION EVALUATION TECHNICAL MEMORANDUM

CDM

Technical Memorandum

MRC WTP Water Quality Studies and Evaluations Project Chemical Dose and Optimization Evaluation

March 18, 2005

Summary

Purpose

A chemical dose and optimization evaluation was conducted to select efficient chemicals and determine optimum chemical doses to treat water in a conventional water treatment plant from the Rio Grande under various conditions throughout the year. Specific design criteria such as dosing order, mixing energy, and pH adjustment was also evaluated. The data will be utilized for design of the Municipal Recreation Complex (MRC) Water Treatment Plant (WTP) planned as part of the Buckman Direct Diversion Project. Additional testing and evaluation may be needed to further define criteria.

Conclusions

The following chemical dosing and design optimization conclusions have been developed based upon the data presented herein.

- All three coagulants (alum, ferric and PACl) performed well during all or some of the testing rounds, though doses of chemicals changed dramatically throughout the year.
- Addition of coagulant aid and flocculant aid polymers improved the settled water quality.
- Dosing the coagulant aid polymer after the coagulant is more effective. Delaying the addition of the flocculant aid polymer one to two minutes after coagulation improved floc size and settling rate.
- The use of a pre-oxidant was effective in improving floc size in combination with ferric chloride.
- A lower alum dose may be satisfactory in achieving similar settled water quality than a higher dose, once optimized. This could not be verified for the other two coagulants.
- Tapered flocculation with a total mixing energy (Gt) of approximately 68,000 was more effective than constant speed flocculation with a total mixing energy (Gt) of 56,100.
- A lowered pH may improve the performance of alum. Additional jar testing to confirm the performance of enhanced coagulation is recommended. PACl and ferric chloride were not effective at a lower pH.

- The removal requirements that were dependent upon the measured TOC and alkalinity at the time of water collection were met by at least one coagulant. However, none of the coagulants were able to achieve the 35 to 40 percent removal percentage that may be required during some periods of the year.
- The settling data collected confirmed a typical sedimentation loading rate of 0.5 to 1.0 gpm/sf will be adequate.

Memorandum Organization

This memorandum outlines the bench-scale testing completed and the following items are presented.

- **Background** – includes information on the testing purpose and the methodologies used for collection of the water, water preparation, laboratory analysis and jar testing.
- **Testing Results** – presents the collected data and compares the results
- **Conclusions** – Summarizes the findings presented under the testing results.

Appendix A presents a list of nomenclature for the reader to refer to for definition of the commonly used terms within this memorandum.

Background

CDM was contracted to complete a water quality study and evaluation related to the conceptual design of the Municipal Recreation Complex (MRC) Water Treatment Plant (WTP) that will be constructed as part of the proposed Buckman Direct Diversion Project. Evaluating successful water treatment chemicals and optimal doses is one aspect of this study. A bench-scale evaluation was completed with the use of jar testing apparatus and laboratory facilities at the City's Canyon Road WTP.

The MRC WTP will receive water from the Rio Grande. Conceptual design of the MRC WTP indicates that a conventional treatment train will be one of the most effective methods of treating Rio Grande water. Conventional treatment normally consists of the following unit processes:

- Rapid Mix – high energy mixing to disperse chemicals added to the raw water to help promote or enhance coagulation
- Coagulation – destabilization of the charge on colloids and solids, including bacteria and viruses with the use of a coagulant chemical
- Flocculation – using gentle mixing to cause the destabilized colloids and solids to collide and agglomerate to form "floc" that is settleable and filterable

- Sedimentation – a quiescent phase where the floc particles settle to the bottom of the basin by gravity, or by other floc particle removal process, producing a clearer water for filtration
- Filtration – particle removal by a granular media consisting of sand, anthracite, or activated carbon
- Disinfection – application of a chemical or ultraviolet light to kill or inactivate microorganisms

Bench scale testing, or jar testing, is a commonly used methodology to evaluate various design parameters for conventional treatment plants. A six mixer system allows for side-by-side comparison of treatment under the various simulated conditions. The design parameters of concern during this evaluation were:

- Comparison of effectiveness of three coagulant chemicals at varying doses;
- Determination of importance of coagulant aid and flocculant aid polymers, as well as dosing order;
- Comparison of two pre-oxidants at various doses;
- Optimization of all chemical doses;
- Effect of differing mixing conditions on treatment;
- Impact of pH adjustment on coagulation and sedimentation processes;
- Removal of organic carbon during coagulation/sedimentation; and
- Measurement of settling rates of raw and treated water.

Jar testing is instrumental in determining what chemicals are important for effective treatment. Jar testing completed throughout the different seasons and changing water conditions is also helpful in developing the ultimate range of chemical feed doses used throughout the year and predicting chemical storage needs. Additionally, the raw water characteristics and selected chemical doses provide valuable design information for solids handling facilities.

Methodologies

Deliberate methodologies for water collection, water preparation, chemical stock preparation, jar testing, and analytical tests were followed throughout the test duration.

Water Collection

All water collected for jar testing was obtained from the Rio Grande at the proposed diversion structure location just south of the end of Buckman Road. A location marker was previously installed within the river during preparation of visual simulation of the area after construction. The marker is located approximately 10 to 15 feet from the shore. Five-gallon jugs and buckets were rinsed with river water and then filled with water from approximately two feet below the water surface to simulate the submerged diversion structure screens. Water temperature, pH, and conductivity were measured at the time of collection with a field meter and the parameters were recorded. River flow at the time of collection was determined from the USGS database for the Rio Grande at Otowi Gaging Station available on the internet. The flow data was useful in assessing if the water was actually collected during the target periods of spring run-off, summer monsoon and fall low-flow by comparison with historical data for the gaging station. After collection, the water was transported to the Canyon Road WTP where the jar testing was completed.

Water Preparation
Water diverted at the Rio Grande will receive preliminary treatment prior to reaching the plant. The diversion structure itself will be equipped with low-velocity fish screens to minimize the potential of entrapment and endangerment of fish. The screens will have 2 millimeter (mm) openings thus material larger than 2-mm, such as twigs, leaves, and rocks will be prevented from entering the diversion structure. Because significant grit and sand size material is expected in the diverted water, removal of particles larger than 0.3-mm is proposed to protect mechanical equipment between the river and the MRC WTP. Lagoons or mechanical separators will be installed near the river to accommodate removal of the material in the range of 0.3 to 2-mm. Two wire mesh stainless steel screens, one with 2-mm openings and the other with 0.3-mm openings were used to screen the collected water to simulate the water arriving at the MRC WTP. Only screened water was used for jar testing. The screened water was stored at the Canyon Road WTP in an area able to maintain the water at collection temperature.

Chemical Stock Preparation
In 1998, CDM prepared and presented a jar testing lesson plan to the staff at the Canyon Road WTP. The lesson plan included specific procedures for chemical stock preparation, jar testing, documentation, and data interpretation. The lesson plan included specific forms and data sheets for computing the quantities of raw and stock chemicals and water to add in preparation of stock solution and dosing of jars. Also a data sheet for recording the jar testing parameters and observations was included in that lesson plan. The procedures outlined in that lesson plan were followed during the testing outlined in this memorandum.

Stock solutions of coagulants, polymers, and other chemicals were prepared for each testing round. The stock preparations were prepared in concentrations of 0.2, 2, or 20 milligrams per milliliter (mg/ml). This simplifies chemical dosing in jar tests because, with a 2 liter (L) jar, 1 milliliter (ml) of solution yields a 0.1, 1, or 10 mg/L concentration, respectively. Relative error is generated when only a small amount of chemical is diluted and the percentage of possible error is large when compared to the volume of chemical used. For example, if only 1 to 2 ml of alum is used to make a stock solution, the relative error caused by the pipette may be 0.1 to 0.2 ml, or 5 to 20 percent. Relative error should consistently be less than 5 percent. Relative error can be minimized by making dilutions using larger volumes such that an error of 1 to

2 ml is acceptable. Therefore, to minimize error in dosing of the jars, the stock solutions were prepared in three steps. The chemical and water volumes were calculated for each stock preparation as the first step. Chemical data (specific weight and solution strength) was obtained from the manufacturer's Material Safety Data Sheet (MSDS) for each chemical. Then, a 20 mg/ml solution was prepared for each chemical for the first stock. The second stock was prepared as either a 0.2 or 2 mg/ml solution depending upon the ultimate dose. Chemicals fed at concentrations of 5 mg/L or greater (mainly the coagulant) were prepared as a 2 mg/ml stock so that at least 5 mls of stock would be added during testing. Chemicals fed at lower concentrations (pre-oxidants and polymers) were mixed as a 0.2 mg/ml stock so that 10 mls of solution would be added to a jar for a dose of 1 mg/L.

Chemicals were obtained from various chemical manufacturers prior to testing. However, aluminum sulfate and cationic polymer C-358 were obtained from Canyon Road WTP. Clean syringes were used to transfer neat chemicals to the stock containers. Volumetric flasks were filled with distilled water to prepare each stock solution. Each stock solution was well mixed on a magnetic stirrer. A second clean syringe was then used to transfer the appropriate volume of the first stock and combined with distilled water for the second stock. The second stock was mixed on the magnetic stirrer. All stock containers were labeled with contents, preparation date, and stock strength. In all cases, the second stock solution was used to feed the appropriate chemical concentrations. The stock solutions were remixed prior to their use. The second stock solution was replenished by mixing a new stock from the first stock as needed.

Jar Testing Procedures

Prior to performing jar testing during a given testing round, a preliminary testing protocol was developed for the testing round. Each testing round had five or six separate objectives that were termed a "testing series." One to five jar tests were performed per test series to meet the objective of that test series. Preparation of the preliminary testing protocol was necessary to predict the water collection volumes, chemical usage, and testing time requirements. Each testing protocol was reviewed by a senior water quality specialist prior to testing.

Three "beaker bars" were used to add the chemicals to all six testing jars at the same time. The beaker bars were constructed with six, 50-ml plastic beakers glued to a wooden bar with feet on either end. The three bars were consistently used for the same chemical and for adding the pre-oxidant, the coagulant, and the coagulant aid polymer. Syringes were used to add flocculant aid polymer to the jars because of the small amount needed and the high viscosity of the second stock solution. These beaker bars were used for all three testing rounds and then given to Canyon Road WTP for their use at the conclusion of testing.

Jar testing data sheets were prepared prior to commencing the jar test. The concentration of each chemical in each jar was noted on the sheet and was based on the testing protocol and the results of previous test(s). Standard jar testing procedures were utilized to evaluate the previously mentioned design parameters of concern. Jar testing simulated rapid mix coagulant dispersion, staged flocculation, and sedimentation processes. Selection of optimum chemical doses and conditions were based upon settled water turbidity, observations of floc size, floc formation speed, floc settling, and jar appearance.

After completion of the data sheet in preparation for the test, the beaker bars' cups were filled with the proper volume of chemicals. The screened water was mixed and samples were collected to measure temperature, pH, and turbidity. Once mixed, the six testing jars were filled with screened water. The jar test apparatus was set up for the selected mixing conditions. Initial mixing energies and times were selected based upon conceptual design criteria for rapid mixing and tapered flocculation. A mixing energy chart versus mixer speed in revolutions per minute (rpm) was referenced for selecting the mixer rpm for the desired mixing energy at the specified temperature. Prior to the start of the test, the mixers were turned on to re-suspend any settleables in jar. Once rotation stopped in the jars, the test was started.

At the start of a test, the jar test apparatus was turned on, the chemicals were added in the noted order and the starting time of the test was noted. The elapsed time when floc slightly larger than pin size had formed was noted on the data sheet. As the test progressed, the appearance of the jar and the floc was watched – a clearer jar with better formed floc was noted as more successful. A clearer jar indicates more effective coagulation (particle destabilization) had occurred and that the colloids and solids were able to properly agglomerate to form floc. A cloudy jar indicates that some of the solids did not coagulate or agglomerate and thus will carry through the sedimentation process onto the filters and may not be filterable. A cloudy jar also can indicate the coagulant chemical was overdosed. At the conclusion of flocculation, the rate of settling of the floc was measured during a two-minute period and recorded on the data sheet. In more successful tests, it was not uncommon for the floc to nearly completely settle before the flocculation period ended and the mixers stopped. Samples were collected from the sample port on the side of the jar after the selected sedimentation period had ended. For most tests, the sedimentation period was 15 minutes in length. The samples were used for the various analytical tests during the three test rounds which included temperature, turbidity, pH, TOC, demand-decay and disinfection testing. The settled water was also tested for dissolved manganese after filtration during the third testing round. Instruments in the Canyon Road WTP laboratory were used for the pH, temperature, and turbidity measurements of the screened and settled water.

Analytical Test Procedures

The main analytical instruments used for this project were laboratory turbidimeters and pH/temperature meters provided in the Canyon Road WTP laboratory. The instrument calibration was verified daily and recalibrated as necessary throughout the testing duration. The measurement of pH and temperature was taken by inserting the probe directly into the raw water bucket or in the 2-L jars. The probe was swirled in the sample until the reading stabilized and then the measurement was recorded. The turbidity samples were collected from the containers and a portion of the sample was used to rinse the turbidity vial and then the sample was added to the vial. The samples were poured slowly onto the side of the vial in an effort to minimize air bubbles that could interfere with the measurement.. The vial was inserted into the instrument and the vial was indexed until the lowest reading was attained. Indexing the vial was recommended to minimize the influence of scratches and imperfections on the vial affecting the turbidity reading. Continual problems with two separate instruments throughout the testing were encountered. Thus, the actual turbidity values may not be reliable and therefore the relative trend and general jar appearance observations are important during data analysis.

Samples collected for outside laboratory analysis were all collected in containers provided by the laboratory. After collection, the samples were placed in a cooler with ice packs and chilled until delivered to the laboratory. Chain of Custody forms were utilized for all outside laboratory analyses.

Testing Results

Raw Water

Raw water quality was measured during the laboratory analysis for other tasks of this project. As anticipated, the raw water quality was significantly different during each round of sampling. Table 1 presents the raw water quality during each testing round.

Table 1. Raw Water Quality

Parameter	First Round (5/21/2003)	Second Round (8/8/2003)	Third Round (10/28/2003)
River Flow, cfs	1100	1030	385
Total Dissolved Solids (TDS)	190	220	260
TOC, mg/L	5.6	3.2-3.6	2.4
Alkalinity, mg/L	100	69	130
Turbidity, NTU	40	59	25
Temperature, deg F	64	73	52
pH	6.5 (8.0)[1]	8.3 (8.0)[1]	8.9
Color, pt co units	20	20	10

[1]The pH was measured with a different meter during collection than during testing. While the field instrument indicated one pH (6.5 or 8.3), the laboratory pH meter indicated the raw water pH was near 8.0 during both rounds

Flow and TOC both decreased each testing round with the highest values occurring during the spring run-off period and the lowest values occurring during low flow. The raw water pH and total dissolved solids concentration increased each testing round. Alkalinity decreased, then increased during the test period.

The goal of the testing was to capture and test water from the various seasons and flow conditions in the river – snow pack run-off, summer monsoon, and fall low flow. Figure 1 compares the median daily streamflow based upon the historical data and the daily mean discharge as measured at the Otowi gaging station.

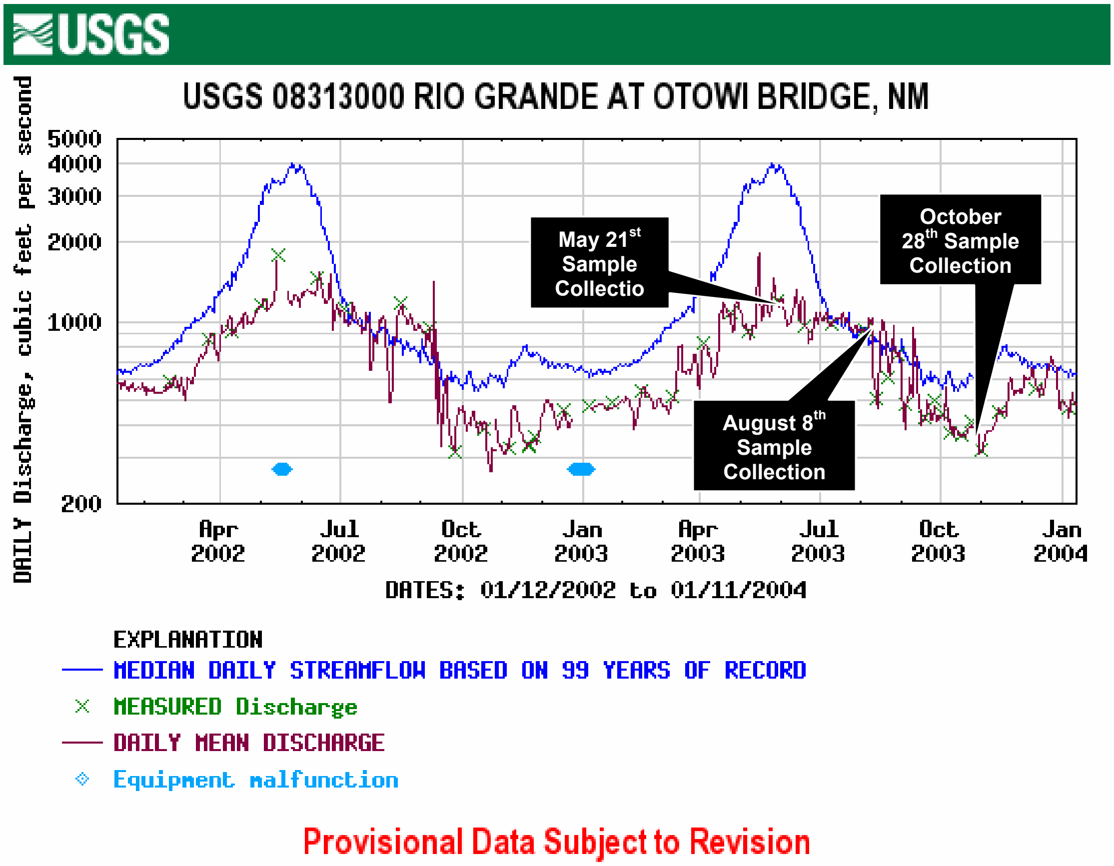


Figure 1. Historical and Actual Rio Grande Streamflow Data Identifying Conditions During Sampling Periods

Based upon the historical data, the high flow occurs in May, the monsoon season is July to August and the low flow is September to October. Figure 1 identifies the sampling dates on the chart and it appears that although the flow rates during the high flow and low flow periods were below normal, sampling did occur during the seasonal high flow and seasonal low flow period. The monsoon period sampling in August was at or near the historical flow for the time period. Therefore, the sampling did meet the objectives of collecting water for testing the three mentioned periods.

Summary of Tests Performed

A total of 52 jar tests were completed throughout the three rounds of testing: 14 during the first round; 23 during the second round; and 15 during the third round. As previously mentioned, each testing round comprised up to six series, with one to eight tests per series. Table 2 summarizes the tests that were performed during each round.

Table 2. Summary of Jar Tests by Testing Round and Series

Series: Objective	First Round Tests	Second Round Tests	Third Round Tests
Series 1: Wide Range Coagulant Doses	1A: 10-60 mg/L alum 1B: 10-60 mg/L ferric 1C: 5-55 mg/L PACl (pH adjusted to 6.5)	1A: 10-60 mg/L alum 1B: 10-60 mg/L ferric 1C: 5-55 mg/L PACl	1A: 10-60 mg/L alum 1B: 10-60 mg/L ferric 1C: 5-25 mg/L PACl (2 types)
Series 2: Narrow Range Coagulant Doses	2A: 25-45 mg/L alum 2B: 20-50 mg/L ferric 2C: 5-30 mg/L PACl (pH adjusted to 6.5)	2A: 27-36 mg/L alum or 4-12 mg/L PACl 2B: 18-42 mg/L ferric	2A: 17-22 mg/L alum or 7-17 mg/L ferric 2B: 3-12 mg/L PACl (2 types)
Series 3: Coagulant Aid and Flocculant Aid Polymer Doses	3A: 30 mg/L alum + 0.5-3 mg/L Cat C-358 3B: 35 mg/L ferric + 0.5-3 mg/L Cat C-358 3C: 15 mg/L PACl + 0.5-3 mg/L Cat C-358 (pH adjusted to 6.5) 3D: 2 jars each coagulant with 1 mg/L Cat Nalco 8105 or Cat L 3E: 30 mg/L alum + 2 mg/L Cat C-358 + 0.1-0.5 Nalco 8181 or 35 mg/L ferric + 1.5 mg/L Cat C-358 + 0.1-0.5 Nalco 8181	3A-1: 27 mg/L alum + 0.15-0.25 mg/L Cat C-358 or Nalco 8105 3A-2: 27 mg/L alum + 1.5-2.5 mg/L Cat C-358 or Nalco 8105 3B-1: 23 mg/L ferric + 0.1-0.2 mg/L Cat C-358 or Nalco 8105 3B-2: 23 mg/L ferric +1-2 mg/L Cat C-358 or Nalco 8105 3C-1: 4 mg/L PACl + 0.1-0.2 mg/L Cat C-358 or Nalco 8105 3C-2: 4 mg/L PACl + 1-2 mg/L Cat C-358 or Nalco 8105 3D: 27 mg/L alum + 1.5 mg/L Nalco 8105 + 0.25-1.0 Nalco 8181 or 23 mg/L ferric + 1.5 mg/L Cat C-358 + 0.1-0.25 Nalco 8181 3E: 23 mg/L ferric + 1.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8181 or 4 mg/L PACl + 0.5 mg/L Cat C-358 + 0.1-0.5 Nalco 8181	3A: 17 mg/L alum + 1-2 mg/L Cat C-358 or 7 mg/L ferric _ 1-2 mg/L Cat C-358 3B: 3 mg/L PACl (2 types) + 0.25-0.5 mg/L Cat C-358 3C: 17 mg/L alum + 1.5 mg/L Cat C-358 + 0.25=0.5 mg/L Nalco 8181 or 7 mg/L ferric + 2 mg/L Cat C-358 + 0.25-0.5 mg/L Nalco 8181 or 3 mg/L PACl + 0.5 mg/L Cat C-358 + 0.25-0.5 Nalco 8181
Series 4: Pre-Oxidant Doses	4A: 30 mg/L alum + 2 mg/L Cat C-358 + 0.5 mg/L Nalco 8105 + 0.5-1.5 mg/L potassium permanganate or 35 mg/L ferric + 1.5 mg/L Cat C-358 + 0.25 mg/L Nalco 8105 + 0.5-1.5 mg/L potassium permanganate 4B: 30 mg/L alum + 2 mg/L Cat C-358 + 0.5 mg/L Nalco 8105 + 1-3 mg/L hypochlorite or 35 mg/L ferric + 1.5 mg/L Cat C-358 + 0.25 mg/L Nalco 8105 + 1-3 mg/L hypochlorite	4A: 27 mg/L alum + 1.5 mg/L Nalco 8105 + 0.5 mg/L Nalco 8105 + 0-5 mg/L potassium permanganate 4B: 27 mg/L alum + 1.5 mg/L Nalco 8105 + 0.5 mg/L Nalco 8105 + 0.75 mg/L potassium permanganate or 23 mg/L ferric + 1.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8181 + 0-0.75 mg/L potassium permanganate or 4 mg/L PACl + 0.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8181 + 0-0.75 mg/L potassium permanganate 4C: 27 mg/L alum + 1.5 mg/L Nalco 8105 + 0.5 mg/L Nalco 8181 + 0-2 mg/L hypochlorite or 23 mg/L ferric + 1.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8181 + 0-1.5 mg/L hypochlorite 4D: 23 mg/L ferric + 1.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8181 + 2 mg/L hypochlorite or 4 mg/L PACl + 0.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8181 + 1-2 mg/L hypochlorite	4A: 17 mg/L alum + 1.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8181 + 0.3-1 mg/L potassium permanganate or hypochlorite 4B: 7 mg/L ferric + 2 mg/L Cat C-358 + 0.5 mg/L Nalco 8181 + 0.3-1 mg/L potassium permanganate or hypochlorite 4C: 3 mg/L PACl + 0.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8181 + 0.3-1 mg/L potassium permanganate or hypochlorite

Table 2. Summary of Jar Tests by Testing Round and Series

Series: Objective	First Round Tests	Second Round Tests	Third Round Tests
Series 5: See test descriptions for objective	Verification and Demand Decay and Disinfection Testing Sample Collection 5A: 30 mg/L alum + 2 mg/L Nalco 8105 + 0.5 mg/L Nalco 8181 + 1 mg/L potassium permanganate or 35 mg/L ferric + 1.5 mg/L Cat C-358 + 0.25 mg/L Nalco 8181 + 1 mg/L potassium permanganate (multiple runs of ferric jars tests completed for sample collection)	Fine Tuning Optimization 5A: Lowered coagulant doses (alum, ferric and PACl) to 23, 18 and 2.5 mg/L respectively 5B: Adjusted pH to 7.0 prior to coagulant addition 5C: Constant speed flocculation 5D: Delayed flocculant aid polymer addition	Fine Tuning Optimization 5A: Lowered coagulant doses and confirmed need for pre-oxidant
Series 6: See test descriptions for objective	None	Comparison of sodium and potassium permanganates and verification of previous results 6A: 27 mg/L alum + 1.5 mg/L Nalco 8105 + 0.5 mg/L Nalco 8105 + 1 mg/L potassium permanganate or 23 mg/L ferric + 1.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8105 + 1 mg/L potassium permanganate 6B: 23 mg/L ferric + 1.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8105 + 1 mg/L potassium permanganate or sodium permanganate or 4 mg/L PACl + 0.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8105 + 1 mg/L potassium permanganate	Settling curve data collection, sample collection and verification of previous results 6A: 4-7 mg/L ferric + 2 mg/L Cat C-358 + 0.5 mg/L Nalco 8181 + 0.5-1 mg/L potassium permanganate 6B: 14-17 mg/L alum + 1.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8181 + 0.5 mg/L potassium permanganate or 3 mg/L PACl + 0.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8181 + 0.65 mg/L potassium permanganate 6C: 14-17 mg/L alum + 1.5 mg/L Cat C-358 + 0.5 mg/L Nalco 8181 + 0.5 mg/L potassium permanganate

Comparison of Effectiveness of Three Coagulant Chemicals at Varying Doses

Three types of coagulants were evaluated during each round of testing: aluminum sulfate (alum); ferric chloride (ferric); and polyaluminum chloride (PACl). The Canyon Road WTP supply of alum (received from DPC Chemical) was used. Ferric chloride was obtained from KemIron Pacific. Several types of PACl were obtained from Gulbrandsen Technologies and KemIron Pacific. Two different PACl formulas were tested and are referred to as GC-850 (Gulbrandsen) and PAX-18 (KemIron). Table 3 presents the chemical information about the four coagulants.

Table 3. Properties of Coagulant Chemicals

Chemical	Specific Gravity	Strength
Aluminum Sulfate	1.335	50%
Ferric Chloride	1.468	44%
PACl: GC-850	1.342	48.9 % Al_2O_3
PACl: PAX-18	1.378	17.09 % Al_2O_3

During the first round of testing, no PACl dose resulted in a good settled water turbidity (less than 1 nephelometric turbidity units (NTU)). A dose of 5 mg/L produced a settled water turbidity of 1.6 NTU in Test 2C. Settled water turbidity actually increased with the addition of the cationic coagulant aid polymer and non-ionic flocculant aid polymer. Therefore, use of PACl was not continued past Series 3 in the first round of testing. The GC-850 was used during the first round. A different PACl chemical was used during the second round (PAX-18) and it performed very well. In the third round, both PACl chemicals were used to determine if the difference in the formulation was the cause of the non-performance during the first round. However, both chemicals performed well during the third round, indicating that the raw water quality may be the cause of the poor performance during the first round.

A wide range (Series 1) and a narrow range (Series 2) of doses of each chemical were tested during each round. The chemical doses were then optimized with the use of cationic and non-ionic polymers and pre-oxidants until final optimized doses were verified in either Series 5 or 6 of the tests. Figure 2 presents the optimized coagulant dose with the use of a pre-oxidant, cationic polymer and non-ionic polymer.

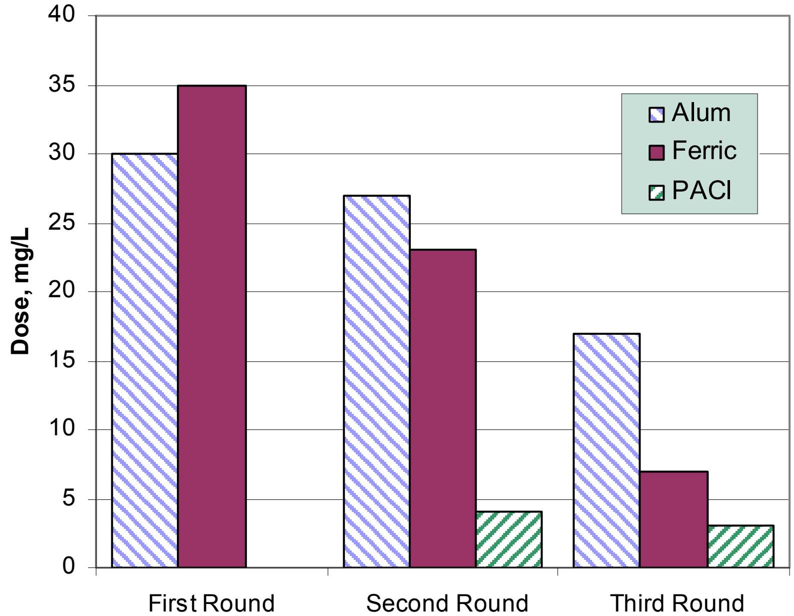


Figure 2. Optimized Coagulant Dose for Each Testing Round

The required coagulant dose decreased each round along with the decreasing TOC and increasing total dissolved solids. However, the optimized doses are based only upon settled water turbidity, settling, floc size and formation speed, and general appearance. The optimized coagulant doses presented in this section do not consider the required and actual TOC removal percentages. Table 4 presents the actual coagulant dose by round and the range for the testing duration.

Table 4. Optimum Coagulant Dose by Testing Round and Dose Range

Coagulant	Chemical Dose, mg/L			
	First Round	Second Round	Third Round	Range
Alum	30	27	17	17-30
Ferric	35	23	7	7-35
PACl	NA	4	3	3-4

NA – PACl (GC-850) did not perform adequately during the first round of testing but GC-850 and PAX-18 both performed well during the other two rounds. Therefore, range does not reflect range possible during entire year.

All coagulants performed well during all rounds, with the exception of PACl during the first round. Alum coagulated more readily and often settled before the flocculation period had ended. Additionally, one large mass of floc would accumulate on the bottom indicating the high attraction forces with the applied dose. Ferric performed similarly in some of the tests. Although PACl performed well at low doses and required low doses of the polymer and pre-oxidant chemicals, the non-performance during spring run-off needs further investigation and could require the use of another coagulant during certain periods of the year. Because the pH was adjusted during use of the PACl in the first testing round, the performance at the raw pH is unknown and may be adequate. Use of PACl may require closer control and jar testing by plant operations staff during its use. It is recommended that the use of all three coagulants be evaluated based upon cost and other concerns before selecting a coagulant or coagulants.

Determination of Importance of Coagulant Aid and Flocculant Aid Polymers and Dosing Order

Water treatment polymers are commonly used as coagulant aids, flocculant aids, and filter aids to improve process efficiency and to reduce the required dose of other chemicals. Coagulant and flocculant aid effectiveness can be tested through jar testing. Filter aids can only be tested through pilot-scale testing. Coagulant aids are used to improve the primary coagulant (usually the metal salts of aluminum sulfate or ferric chloride) performance and often result in a lowered primary coagulant dose and less sludge production. Flocculant aids help produce floc that is larger and denser and thus settles easier and faster.

Series 3 of each testing round evaluated the effectiveness of the addition of a coagulant aid (cationic) polymer and a flocculant aid (non-ionic) polymer. Three different cationic polymers and one non-ionic polymer were used during the testing. However, the purpose was not to evaluate different chemicals but only to determine if their use was effective and should be included in the MRC WTP chemical system design.

In general, a reduction in the settled water turbidity and an increase in the floc size, speed of formation, and setting rate were seen through the addition of both coagulant aid and flocculant aid polymers. For instance, during Series 2 of the third round of testing, the coagulants were dosed with potassium permanganate only. The settled water turbidity, without the use of polymers, was over 1.0 NTU with all three coagulants. However, with the addition of both polymers, the settled water turbidity dropped dramatically for all three coagulants. This is shown in Figure 3.

The addition of the coagulant aid to the alum actually increased the settled water turbidity slightly as shown in Figure 3. This was not the case during the first and second rounds of testing and a reduction in settled water turbidity was observed in those tests. Although not shown in Figure 3, the addition of the coagulant aid did decrease the floc formation time for alum.

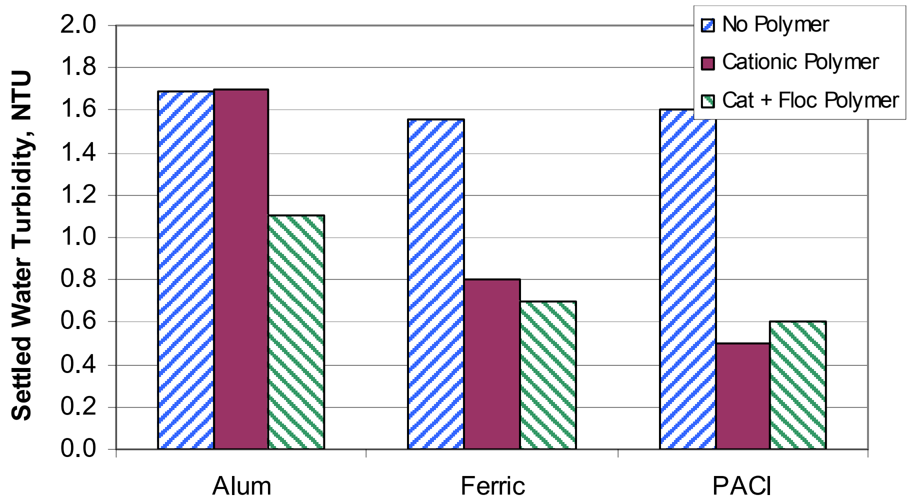


Figure 3. Settled Water Turbidity During the Third Round of Testing with and without Polymers

Once the flocculant aid was added to the water with all three coagulants, the floc settling increased dramatically and in most cases the floc settled before the end of the flocculation period. In these cases, the floc settling rate could not be measured but the better settling resulted in lower settled water turbidities. The use of the two polymers resulted in the best performance of all the tests with clear jars, good floc size and structure, lowest settled water turbidity, and good settling.

The proper chemical application sequence is important for obtaining the best water quality and reducing overall chemical costs. Therefore, jar tests were completed to compare the effect of changing the dose sequence and timing of the polymer addition. During the second round of testing, the sequence of the coagulant and coagulant aid polymer was compared. During Tests 3D and 3E (and nearly all other tests during first and second rounds), the coagulant aid polymer was fed just before the coagulant and the floc aid was fed last with a 30-second delay. During Test 5D, the order was switched with the coagulant aid being fed one-minute after the coagulant and the flocculant aid being fed after another 15-seconds. The coagulant doses are shown in Table 2 for the second round. Other chemical doses were as follows: potassium permanganate-1 mg/L; cationic polymer-1.5 mg/L (with ferric and alum) or 0.5 mg/L (with PACl) and non-ionic polymer - 0.5 mg/L. The results of Test 5D indicate the preferred sequence is coagulant, coagulant aid, then flocculant aid. The settled water turbidity increased slightly (0.1 to 0.2 NTU) with this configuration, but there were significant increases in the floc size and settling rate and the turbidity difference could be attributable to instrument error. Only PACl settled almost completely before the sedimentation period started with the first configuration in tests 3D and 3E (coagulant aid then coagulant). With the second configuration, alum and PACl both settled nearly completely before the sedimentation period began and the ferric had a higher settling rate. The second sequence (coagulant then coagulant aid) was used during the third round.

Delaying the addition of the flocculant aid polymer until pinpoint floc formation commonly improves the size and weight of the floc. Most of the jar tests completed during the second round utilized a 30-second delay before addition of the flocculant aid. Testing if additional delay was beneficial was completed in Tests 6A and 6B. During Test 6A, alum and ferric were tested with a 1-minute delay. During Test 6B, ferric and PACl were tested with a 2-minute delay. The results of Tests 6A and 6B were compared with the results of the floc aid dose testing during tests 3D and 3E. The chemical doses were the same as discussed in the above paragraph. For alum, the 1-minute delay resulted in larger floc (2-mm versus 1.2-mm) and a faster settling rate. For ferric, there was no clear improvement with a 1-minute delay. However, the 2-minute delay showed dramatic improvement as the size increased from 1.5 to 2.0-mm and the formation speed decreased. The settling rate also increased. The size of the floc with a 2-minute delay along with PACl also showed a dramatic increase in the floc size (1.5 to 2.3-mm). The increases in floc size are shown in Figure 4.

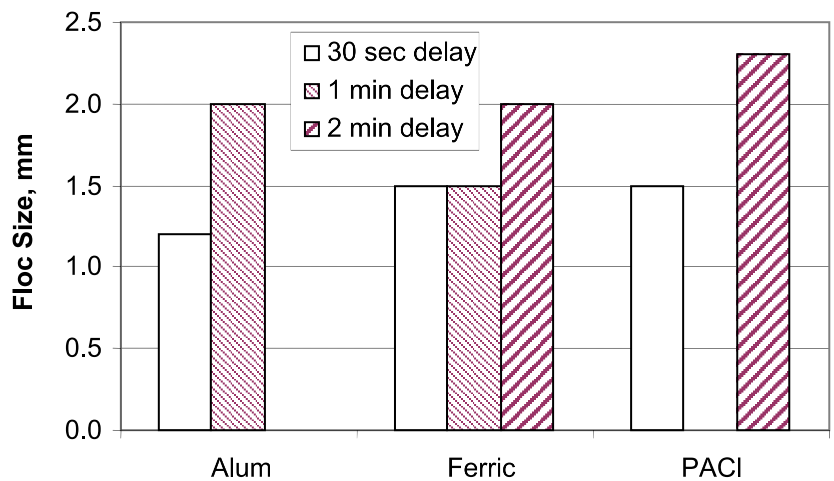


Figure 4. Effect of Flocculant Aid Dosing Delay on Floc Size during the Second Round of Testing

Both the dosing order and the delay are important in the optimal design and operation of the treatment plant. Also, the need for flexibility in treating the varying water quality is important.

Comparison of Two Pre-Oxidants at Various Doses

Operating experience has shown that applying a pre-oxidant to raw water prior to coagulation results in larger and faster floc formation and sometimes a lowered coagulant dose requirement. In fact, CDM completed jar testing at the Canyon Road WTP in October 1996 that showed the addition of 1.4 mg/L chlorine from sodium hypochlorite as a pre-oxidant resulted in larger floc (0.3-mm to 0.5-mm) at the same alum dose (20 mg/L) and that the same size floc (0.3-mm) could be produced at a slightly lowered 15 mg/L dose. However, the addition of chlorine based pre-oxidants can cause significant formation of disinfection by-products (DBPs) in source waters with TOC concentrations above 2.0 mg/L. The Rio Grande water has a TOC concentration above 2.0 mg/L. Therefore, other pre-oxidants, such as potassium and sodium permanganate, are often evaluated and used in place of chlorine. Though permanganate is a weaker oxidizing agent than chlorine, it is effective in treating taste and odor constituents. However, permanganate use can be troublesome in the distribution system if the dissolved manganese comes out of solution and creates brown water, as recently happened in Santa Fe. The advantages and disadvantages of each type of pre-oxidant must be evaluated in combination with their performance. Additional information on DBPs can be found in the technical memorandum prepared by CDM titled *MRC WTP Water Quality Studies and Evaluations Project Disinfection By-Product Study*. TOC is discussed in detail in another technical memorandum prepared by CDM entitled *MRC WTP Water Quality Studies and Evaluations Project Organics and TOC Evaluation.*

To evaluate the need for a pre-oxidant, tests were completed that compared the settled water quality using optimized chemical doses with and without a pre-oxidant. Tests 4A through 4C during the second round compared both ferric chloride and alum with and without each pre-oxidant. Test 5A during the third round compared ferric chloride with and without each pre-oxidant. During all three rounds of testing, potassium permanganate was used as the primary pre-oxidant. During the second round, the use of a pre-oxidant did not result in significant improvements in the floc quality, settling, or turbidity in the jars with the optimum alum dose of 27 mg/L. The settled water turbidity without a pre-oxidant ranged from 0.3 to 0.75 NTU. With a pre-oxidant, the settled water turbidity ranged from 0.41 to 1.1 NTU. The settled water turbidity was even high when hypochlorite was used. Ferric chloride did not perform as well as alum without a pre-oxidant. The use of a pre-oxidant showed a significant increase in the floc size and a decrease in settled turbidity with the optimum dose of ferric chloride (23 mg/L). The settled turbidity without a pre-oxidant, with permanganate, and with hypochlorite was measured as 1.27 mg/L, 0.24 mg/L (1 mg/L potassium permanganate) and 1.1 mg/L (1.5 mg/L dose of hypochlorite), respectively. The size increased from 1.5-mm to 2-mm and 2.3-mm with the same dose. During the second round, the settled water turbidity was measured at 0.7 NTU with the optimum ferric chloride dose (7 mg/L) and no pre-oxidant. Settling was nearly complete before the flocculation period ended with this test. The use of a pre-oxidant increased the settled water turbidity with most comparison tests using hypochlorite. One test with hypochlorite showed a decrease in the turbidity (0.5 NTU) but a verification of the test did not have the same positive results (1.1 NTU). It is likely that the turbidity measurements were inaccurate because of the ongoing problems with the laboratory turbidimeters. A comparison of the other parameters (floc size, formation speed, and settling rate) confirmed that the water quality did not improve with the use of hypochlorite. The use of potassium permanganate (0.5 to 0.65 mg/L) did improve the water quality with the optimized ferric chloride dose of 7 mg/L. Settled water turbidity improved only slightly. However, the floc size increased from 1.5-mm to 2.3-mm with a 0.65 mg/L dose of potassium permanganate.

During Series 4 of each round, various permanganate and hypochlorite doses were evaluated to determine the optimum dose for each coagulant. For comparison, Figure 5 shows the settled water turbidity for each testing round of each pre-oxidant. The doses for each of the tests that resulted in the lowest turbidity are shown in the chart.

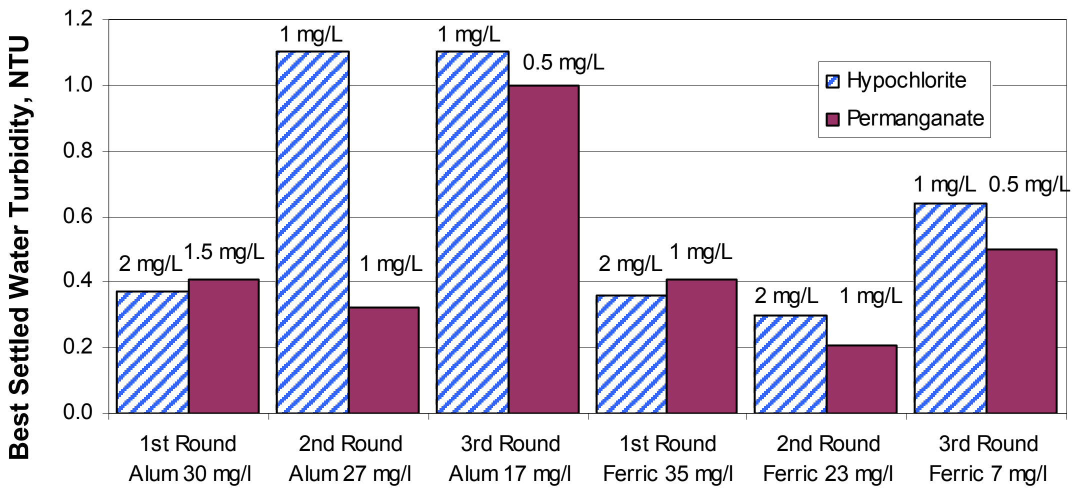


Figure 5. Comparison of Settled Water Turbidity with Optimum Doses of Hypochlorite and Potassium Permanganate During all Rounds of Testing

Figure 5 shows that the settled water turbidity for each of the two pre-oxidants was similar during most tests. In general, the potassium permanganate tests had settled water turbidity nearly the same or lower than hypochlorite at the same or lower doses in all cases.

A final comparison was made between potassium permanganate and sodium permanganate to determine if there were significant differences in the performance of either chemical. During Test 6B of the second round, ferric chloride was tested with both types of permanganate. Both permanganates performed well at a dose of 1 mg/L resulting in settled water turbidities of approximately 0.4 NTU in both jars. The potassium permanganate jar had slightly larger floc (1.5-mm versus 2-mm) and settled slightly better (5 centimeters per minute (cm/min) versus 6 cm/min). This was the only test completed to compare the two chemicals. Because of the fairly limited differences the ultimate selection of the chemical may come down to operator preference – dry or liquid.

The decision of which pre-oxidant to use should be based upon the final selection of the primary coagulant and a review of the potential for DBP formation with hypochlorite or the potential for dissolved manganese to precipitate in the distribution system.

Optimization of all Chemical Doses

Each type of chemical was tested in a step-by-step procedure until an optimal dose of each was chosen. Then, additional testing was completed to determine if further optimization could be completed.

During Series 1, a wide-range coagulant dose (i.e. 10 to 50 mg/L) was selected for each of the three coagulants. Then, in Series 2, a narrow-range coagulant dose (such as 20 to 35 mg/L) was tested. The lowest dose resulting in the best floc behavior and settled water turbidity was selected to carry through with the other testing. In some cases, a higher dose of coagulant resulted in a slightly reduced turbidity but the extra chemical costs would not be justified for the return. Therefore, the lower dose would be used for the remaining tests.

During Series 3, the coagulant aid and flocculant aid polymers were tested over a range (0.5 to 2 mg/L for coagulant aid and 0.25 to 1 mg/L for flocculant aid). Based upon their performance, the optimum dose was selected and used for the subsequent tests. Similar to the coagulant, the lowest dose with good results was selected. During Series 4, the two pre-oxidants were compared over a range. The best performing potassium permanganate dose was carried through in all cases because it was assumed that the minimal added benefit from hypochlorite was not worth the additional DBP formation. Potassium permanganate was also used during Series 1, 2 and 3. During either Series 5 of 6, additional tests were performed that evaluated if a lower coagulant dose resulted in similar settled water quality.

During the third round of testing, the settled water TOC was also compared for the optimized and the lowered coagulant doses. Table 5 presents the optimized chemical doses, by chemical and testing round. The optimized dose of each coagulant was lowered significantly with each subsequent testing round. Ferric chloride appeared to be successful at lower optimized dose, but completion of TOC testing during the third round indicated the lowered dose did not adequately remove TOC. Alum was successful, with good TOC removal during the third round of tests. The PACl dose was not lowered in combination with TOC testing, so a lowered optimized dose was not confirmed.

Table 5. Comparison of Optimized Chemical Doses During Each Round of Testing

Chemical	First Round			Second Round			Third Round		
	Alum	Ferric Chloride	PACL	Alum	Ferric Chloride	PACL	Alum	Ferric Chloride	PACL
Pre-Oxidant	1	1	NA	1	1	1	0.5	0.5	0.65
Coagulant	30	35		27	23	4	14	7	3
Coagulant Aid	2	1.5		1.5	1.5	0.5	1.5	2	0.5
Flocculant Aid	0.5	0.25		0.5	0.5	0.5	0.5	0.5	0.5

NA - Not successful at any dose but pH was adjusted to 6.5 only during the first round.

Effect of Differing Mixing Conditions on Treatment

Conceptual design criteria for the MRC WTP were presented in Appendix C of *Buckman Surface Diversion Project: Project Description and Preliminary Construction, Operations, and Maintenance Plan Report* (February 13, 2002). The conceptual design criteria were based upon an assumption that the treatment plant would be a conventional plant. Jar testing mixing conditions for both rapid mixing and flocculation were based upon the conceptual design criteria as shown in Table 6.

Table 6. Conceptual Design Criteria and Jar Testing Criteria

Component	Conceptual Design Criteria		Typical Jar Testing Criteria	
	Detention Time	Mixing Energy G, sec^{-1}	Detention Time	Mixing Energy G, sec^{-1}
Rapid Mixing	1 second	1000	5 seconds	330-420
Flocculation	30 minutes: 3 stages at 10 minutes each	Stage 1: 40-80 Stage 2: 40-60 Stage 3: 10-40	30 minutes: 3 stages at 10 minutes each	Stage 1: 60 Stage 2: 40 Stage 3: 10
Sedimentation	15 minutes	0	15 minutes	0
Total Gt	55,000 – 109,000		67,650 – 68,100	

During the jar testing, the maximum rotation speed on the jar test apparatus was used (300 rpm) resulting in a mixing energy of 350 to 410 sec^{-1} depending upon temperature. The detention time during rapid mixing was increased from the conceptual design criteria to allow for sufficient time to add the chemicals and assure mixing. The overall Gt used during testing was about 25 percent above the low conceptual design criteria value. Tapered flocculation with mixing conditions similar to that shown in Table 6 was used for nearly all jar tests through all three testing rounds. However, one test during the second round (Test 5C) evaluated a constant speed flocculation rather than tapered flocculation. The total mixing energy during the constant speed test was 56,100.

Figure 6 shows the settled water turbidity differences with the use of tapered versus constant speed flocculation. The settled water turbidity was significantly less with the tapered flocculation. Although not shown in Figure 6, the formation speed and settling rate was similar for all coagulants with both mixing schemes. The floc size was similar (alum) or smaller (ferric and PACl) with the constant speed flocculation.

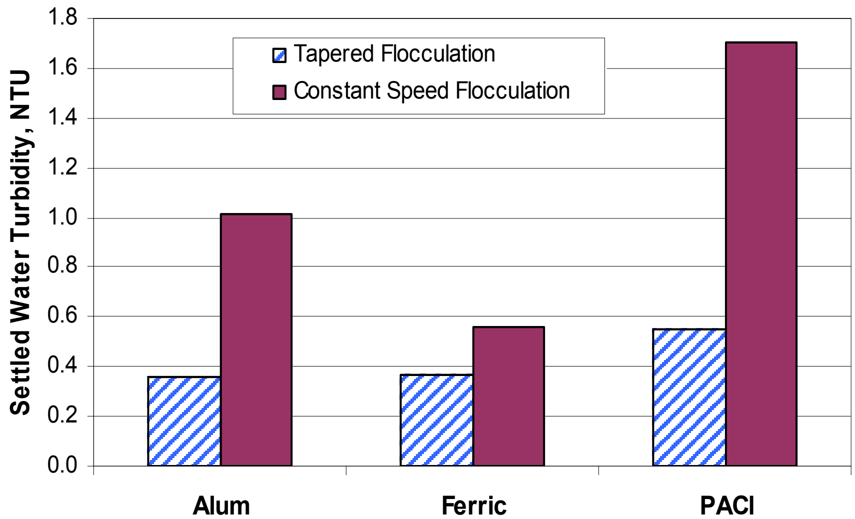


Figure 6. Comparison of Settled Water Turbidity for Tapered and Constant Speed Flocculation

Impact of pH Adjustment on Coagulation and Sedimentation Processes

The raw water pH during the three rounds of testing was 7.8 to 8.0, 8.0 and 8.9 as measured with the Canyon Road WTP pH meter. Coagulants often perform better at a pH of 5.5 to 7.0. Additionally, the reduction of pH prior to the use of the coagulant can improve TOC removal by what is commonly known as "enhanced coagulation." Tests were completed to compare the effect of a lowered pH on the finished water quality. During the first round of testing, PACl was tested at a pH of 6.5 with poor results. The pH of the water was lowered through the addition of sulfuric acid. Because PACl performed well during the other two rounds of testing without pH adjustment, it is possible that the pH adjustment caused the inadequate performance during the first round. The affect of pH adjustment on the settled water quality with alum and ferric chloride was evaluated in Test 5B in the second round. This test also evaluated if the optimized coagulant dose could be reduced after the other chemical doses were optimized. Therefore, the coagulant dose was slightly lower than in the other tests in second round. The alum dose was reduced from 27 mg/L to 23 mg/L. The ferric chloride dose was reduced from 23 mg/L to 19 mg/L. For both coagulants, the pH was adjusted to approximately 7.0 before commencing the jar test. Two tests with each coagulant were conducted, one at the normal pH, the other at a depressed pH. The settled water turbidity for all four tests was similar and ranged from 0.5 to 0.7 NTU. The jars with the adjusted pH had slightly lower settled water turbidities. However, because of the inaccuracies with the turbidimeter, it is unclear if the measurements are accurate, so performance differences should be evaluated from other parameters. With ferric chloride, the lowered pH jar settled slower (3 cm/min instead of 4 cm/min). With alum, the other characteristics and appearance of the jars were similar.

The limited information indicates that pH adjustment may be beneficial with alum. Another chemical could be used to achieve this effect, acidified alum, so the pH adjustment and coagulant addition occurs in one step. The pH adjustment may not be beneficial with the use of ferric chloride or PACl.

Removal of Organic Carbon during Coagulation/Sedimentation

Removal of organic carbon through the treatment process is regulated under the Stage 1 Disinfectants/Disinfection By-Products Rule (DBPR). The DBPR requires that a certain percentage of the raw TOC be removed by treatment, depending upon the raw water TOC concentration and alkalinity, in order to reduce DBPs formed through the breakdown of organic material by disinfectants. TOC samples were collected for laboratory analysis during the second and third testing rounds once all chemical doses were optimized. During the second round, samples were collected from settled water during tests 6A and 6B. Settled water was collected from the sample drain on the 2-liter jars into one composite sample and the sample bottle was filled from the composite sample. During the third round of testing, only one 2-liter jar was used per test (Tests 6A through 6C) and the sample was collected directly from the sample drain after flushing. The samples were filtered through a 0.45 micron filter and then the sample bottle was filled. Although only the third round samples were filtered, the raw water consisted mainly of dissolved organic carbon (DOC) and therefore filtering probably would not have resulted in a significant difference in the TOC concentration. Table 7 presents the TOC concentration and removal percentage achieved for each coagulant and the respective chemical doses.

The raw water TOC presented in Table 7 shows a range of values. The range is based upon the result of DOC analysis being slightly higher than TOC. Since DOC is a component of TOC, it has to be equal to or less than TOC. According to the laboratory, the standard error for both parameters is 0.5 mg/L and therefore the difference (0.4 mg/L) is within the accepted error. The range shown is the two reported numbers for TOC and DOC.

Table 7. Settled and Filtered Water TOC Concentrations and Removal Percentages

Second Round – Raw Water TOC = 3.2 – 3.6 mg/L Settled Water Sampled			Third Round – Raw Water TOC = 2.4 mg/L Settled and Filtered Water Sampled		
Chemical Doses	**TOC**	**% Removed**	**Chemical Doses**	**TOC**	**% Removed**
Potassium permanganate – 1.0 mg/L Ferric chloride – 23 mg/L Cationic polymer Nalco 8105 – 1.5 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	2.5 mg/L	21.9 – 30.6	Potassium permanganate – 0.5 mg/L Ferric chloride – 7 mg/L Cationic polymer C-358 – 2.0 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	2.2 mg/L	8.3
Potassium permanganate – 1.0 mg/L Alum – 27 mg/L Cationic polymer C-358 – 1.5 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	2.9 mg/L	9.4 – 19.4	Potassium permanganate – 0.5 mg/L Ferric chloride – 4 mg/L Cationic polymer C-358 – 2.0 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	2.4 mg/L	0
Potassium permanganate – 1.0 mg/L Polyaluminum Chloride (PAX-18) – 4 mg/L Cationic polymer Nalco 8105 – 0.5 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	2.7 mg/L	15.6 – 25.0	Potassium permanganate – 0.5 mg/L Alum – 17 mg/L Cationic polymer C-358 – 1.5 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	2.0 mg/L	16.7
			Potassium permanganate – 0.5 mg/L Alum – 14 mg/L Cationic polymer C-358 – 1.5 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	1.9 mg/L	26.3
			Potassium permanganate – 0.65 mg/L Polyaluminum Chloride (PAX-18) – 3 mg/L Cationic polymer C-358 – 1.5 mg/L Non-ionic polymer Nalco 8181 – 0.5 mg/L	1.9 mg/L	26.3

Removal requirements from the DBPR are based upon the raw water TOC and alkalinity. This data is presented in Table 4 of the technical memorandum prepared by CDM entitled *MRC WTP Water Quality Studies and Evaluations Project Organics and TOC Evaluation*. The TOC and alkalinity during the water collection period for the second and third rounds indicate a 25 percent and 15 percent removal requirement for each period, respectively. However, historical water quality data in the river measured at the Otowi Gaging Station indicate the average removal requirement would be 25 to 35 percent.

Considering the range of TOC, the removal achieved with the three coagulants during the second round ranged from 9.4 to 30.6 percent, with ferric chloride resulting in the highest removal percentage. During the third round, the removal percentage ranged from 0 to 26.3 percent, with alum resulting in the highest removal percentage. The 0 percent occurred while trying to lower the optimum ferric chloride dose. The optimum alum dose was also lowered, but the lowered dose resulted in an increased removal percentage (16.7 to 26.3 percent). The PACl removal was similar during both rounds and met the actual requirements. However, PACl could not be optimized during the first round when tested at a lower pH. Ferric chloride performed well during the second testing round but did poorly during the third testing round. Alum did the opposite. None of the doses or coagulants tested achieved a removal requirement of 35 to 40 percent, the probable high removal requirement determined from historic Rio Grande water quality data at the Otowi gaging station.

Measurement of Treated Water Settling Rates

Settling rates were measured during all tests with the use of a ruler and recording the distance the sludge settled in two minutes – measured as cm/min. However, the continued mixing after flocculation stopped and the inaccuracies of not measuring all jars at once make the measurements only estimates. A more accurate methodology involves measuring the settled water turbidity over time by drawing samples from the sample port located 10 cm below the water surface. The settling curve derived from the data can be converted to an overflow rate for design purposes. Additionally, the effectiveness of different chemical doses can be compared with the methodology. During Tests 6A through 6C in the third round, settled water turbidity was measured at timed intervals for each of the three coagulants. Figure 7 presents the collected data showing the measured turbidity versus the settling time for all tests.

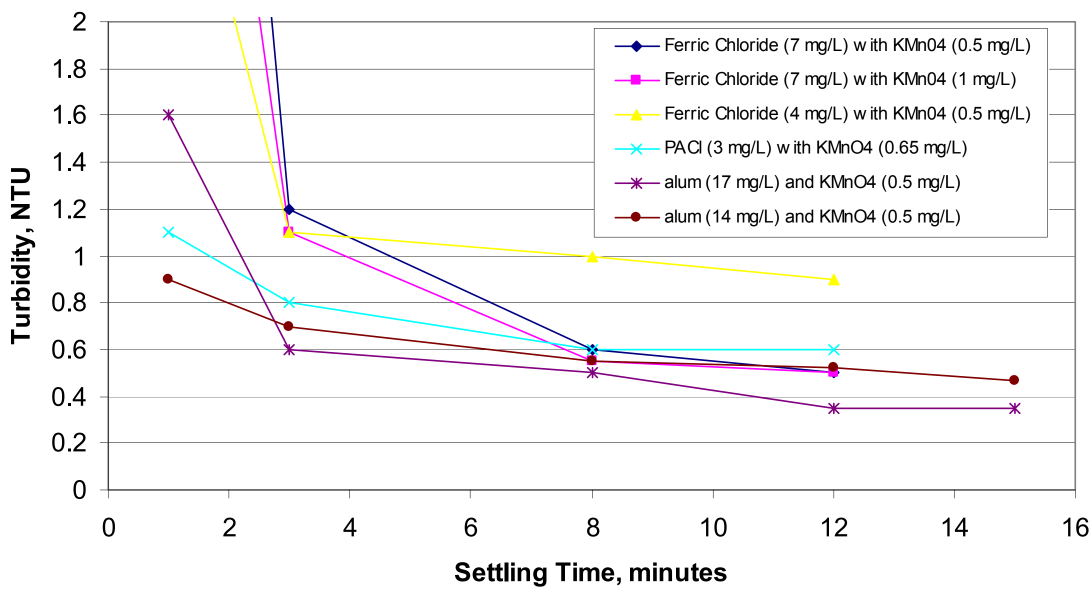


Figure 7. Comparison of Settled Water Turbidity Versus Time during the Third Round of Testing

The chemical doses shown in Figure 7 also tested the effect of lowering the optimized coagulant dose once all chemical doses were optimized. As shown in Figure 7, the alum and PACl jars settled faster than the ferric chloride jars. The lower dose of alum (14 mg/L) was nearly as effective as the 17 mg/L dose – this conclusion is confirmed by the TOC removal percentages for the two doses of alum shown in Table 7. The 4 mg/L lowered dose of ferric chloride was not as effective as the original optimized dose of 7 mg/L as the settling rate for this configuration was the slowest of all the tests. This is also confirmed by the TOC removal results. Only a very slight improvement in settling was noticed through the increased potassium permanganate dose (0.5 mg/L to 1 mg/L) and the difference could be a turbidity instrument error.

The data presented in Figure 7 can also be converted into a settling rate versus percent raw water turbidity remaining. For the third round of testing, the raw water turbidity was measured as 25 NTU. The measured timed turbidities were divided by the original raw water turbidity to calculate the remaining raw water turbidity percentage. The settling times when turbidity samples were taken were divided by 10 cm (the distance from the water surface in the jar to the sample port) to calculate the settling rate in cm/min. The remaining raw water turbidity percentage defines the portion of the raw-water turbidity that settles at a rate equal to or less than the corresponding settling velocity. The settling velocity can also be converted to a surface loading rate with a settling velocity of 4.0 cm/min being approximate to a loading rate of 1.0 gallon per minute per square foot (gpm/sf). Figure 8 displays settling velocity versus the percentage of raw water turbidity remaining. Depending upon the goal for percent raw water turbidity remaining set for the sedimentation process (i.e. 5 percent remaining, 1 NTU, etc.) the settling velocity and thus design loading rate (settling velocity divided by 4, approximately) can be chosen from the chart presented as Figure 8.

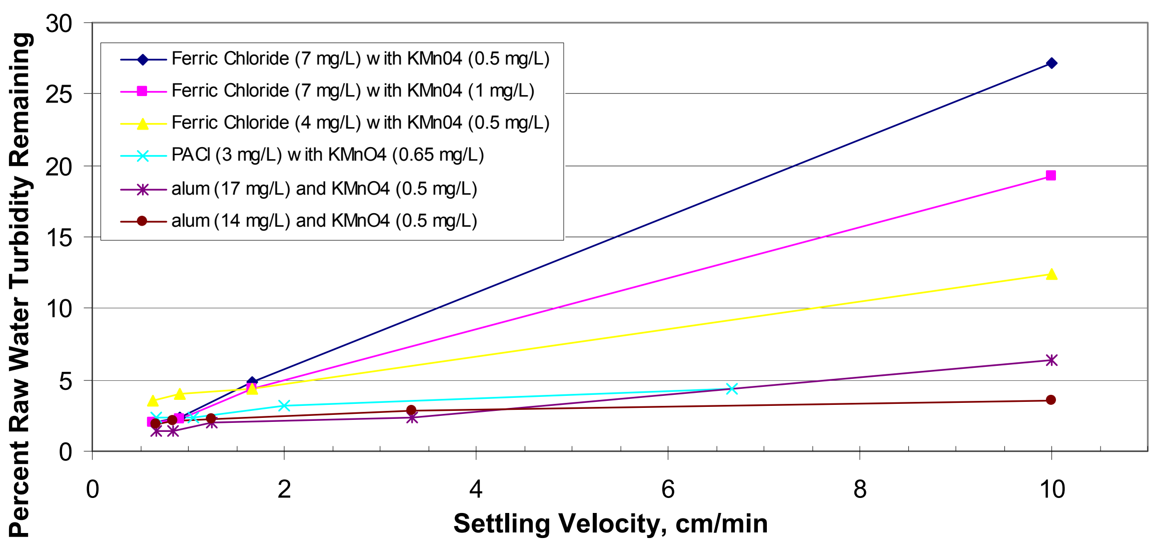


Figure 8. Percent Raw Water Turbidity Remaining Versus Settling Velocity during the Third Round

If the goal is to reach 1 NTU during sedimentation, for a raw water turbidity of 25 NTU, this equates to a percent raw water turbidity remaining of 4 percent. Only alum, at a dose of 14 mg/L, was able to achieve this reduction at a loading rate equal to or greater than 2.5 gpm/sf.

However, settling was only tested with this methodology during the third round of testing when the raw water had the lowest raw water turbidity of the three rounds. Because the coagulants performed differently during each period and the data is limited, a more conservative loading rate, such as 0.5 or 1 gpm/sf, is a safe approach. From Figure 8, a loading rate of 1 gpm/sf is equal to a settling velocity of 4 cm/min and the percent turbidity remaining ranges from three to 12 percent, depending upon the coagulant and dose.

Conclusions

The following chemical dosing and design optimization conclusions can be made based upon the data presented herein.

- All three coagulants (alum, ferric and PACl) performed well during all or some of the testing rounds and the use of each should be further evaluated.
- The optimum coagulant dose changes dramatically throughout the year.
- Both a coagulant aid and a flocculant aid polymer improved the settled water quality.
- Dosing the coagulant aid polymer after the coagulant is more effective.
- Delaying the addition of the flocculant aid polymer one to two minutes after coagulation improved floc size and settling rate.
- Use of a permanganate pre-oxidant was effective in improving floc size in combination with ferric chloride.
- Use of hypochloride as a pre-oxidant did not improve flocculation performance or settled water turbidity.
- Both potassium and sodium permanganate performed similarly and there was no apparent difference in their effectiveness.
- A lower alum dose may be satisfactory in achieving similar settled water quality than a higher dose, once optimized. This could not be verified for the other two coagulants.
- Tapered flocculation with a total mixing energy (Gt) of approximately 68,000 was more effective than constant speed flocculation with a total mixing energy of 56,100.
- A lower raw water pH may improve the performance of alum. Additional jar testing to confirm the performance of enhanced coagulation is recommended.
- PACl and ferric chloride were not effective at a lower pH.
- The TOC removal requirements, dependent upon the measured raw water TOC and alkalinity at the time of water collection, were met by at least one coagulant.
- None of the coagulants were able to achieve the 35 to 40 percent removal percentage that may be required during some periods of the year.

- The settling data collected confirmed a typical sedimentation loading rate of 0.5 to 1.0 gpm/sf will be adequate.
- The doses of each chemical will vary throughout the year, by coagulant, as shown in Table 8.

Table 8. Range of Optimized Chemical Doses

Chemical	Dose Range, mg/L
Pre-Oxidant	0.5 – 1.0
Alum	14 – 30
Ferric Chloride	7 - 35
PACl	3 – 4[1]
Coagulant Aid	0.5 – 2.0
Flocculant Aid	0.25 – 0.5

[1]The potential high end dose was not determined as the testing during the first round was unsuccessful

Appendix A
Common Nomenclature

ACRONYMS / NOMENCLATURE

Alum	Aluminum Sulfate, Coagulant Chemical
C-358	Cationic Coagulant Aid Polymer
Cat	Cationic Coagulant Aid Polymer
Cat L	Cationic Coagulant Aid Polymer
CDM	Camp Dresser & McKee
cm	Centimeters
cm/min	Centimeters per Minute
DBPs	Disinfection By-Products
DOC	Dissolved Organic Carbon
Ferric	Ferric Chloride, Coagulant Chemical
Floc Polymer	Non-Ionic Flocculant Aid Polymer
GC-850	Type of Polyaluminum Chloride
gpm/sf	Gallons per Minute per Square Foot
KMnO4	Potassium Permanganate
mg/L	Milligrams per Liter
mg/ml	Milligrams per Millileter
ml	millileter
mm	Millimeter
MRC	Municipal Recreation Complex
NA	Not Available
Nalco 8105	Cationic Coagulant Aid Polymer
Nalco 8181	Non-Ionic Flocculant Aid Polymer
NM	Not measured
NTU	Nephelometric Turbidity Units
PACl	Polyaluminum Chloride, Coagulant Chemical
PAX-18	Type of Polyaluminum Chloride
rpm	Revolutions per Minute
TOC	Total Organic Carbon
USGS	United States Geological Survey
WTP	Water Treatment Plant

APPENDIX G
DISINFECTION BY-PRODUCT STUDY TECHNICAL MEMORANDUM

Technical Memorandum

MRC WTP Water Quality Studies and Evaluations Project Disinfection By-Product Study

March 18, 2005

Summary

Purpose

The purpose of this memorandum is to summarize the formation potential of two main disinfection by-products (DBPs) groups generated during disinfection processing in a drinking water system, Total Trihalomethanes (TTHMs) and Haloacetic Acids (HAAs). Three separate disinfection processes were considered to determine the potential DBP problems for the Buckman Direct Diversion Project.

Conclusions

Three primary disinfectants were used (including chlorine for secondary disinfection) to simulate DBP formation potential during this study: chlorine, chlorine dioxide, and ozone. The results of the analyses show that DBP formation was most significant when using only chlorine as a disinfectant, and least significant when using both chlorine dioxide and chlorine for disinfection. DBPs were formed during the ozone and chlorine dioxide tests because chlorine was added as a secondary disinfectant in both cases. Ozone produced 14 percent less TTHMs and 19 percent less HAAs than chlorine for this water sample. Chlorine dioxide produced 33 percent less TTHMs and 25 percent less HAAs than chlorine. These results indicate that use of ozone or chlorine dioxide disinfection should minimize DBP formation for this water. However, the testing was not completed under optimized total organic carbon (TOC) removal conditions. The TOC removal requirements will exceed 40 percent in some months and therefore the DBP formation potential will be significantly lowered, allowing the use of a chlorine based chemical (sodium hypochlorite) as a secondary disinfectant.

Background

Regulatory activity pertaining to disinfection and disinfection by-products (DBPs) has accelerated in the last several years. Disinfectants themselves can react with naturally-occurring constituents in drinking water to form by-products which may pose health risks. Pathogens, such as *Cryptosporidium*, can cause illness and are typically resistant to traditional disinfection practices. Disinfection design approaches must protect the public health from the chronic and acute risks of DBPs, while conforming to the USEPA's Safe Drinking Water Act regulations. The balance of disinfection benefits and risks will continue to challenge designers while meeting the increasingly stringent regulations.

DBP formation is a common occurrence in surface water treatment plants because chlorine is, by far, the most commonly used disinfectant (primary and secondary disinfection) in the United States. Chlorine reacts with natural organic matter (NOM) and bromide to form halogenated compounds, such as TTHMs and HAAs.

Various disinfectants (ozone, chlorine dioxide, etc.) react with NOM to form different DBPs. While chlorine predominantly produces halogenated organics, ozone produces aldehydes, ketones, and inorganic by-products. Chlorine dioxide produces chlorate and chlorite, and while in the presence of bromine, ozone produces bromate. Therefore, the type and amount of DBPs generated during treatment depends on the type and dose of disinfectant, as well as the water quality, treatment sequences, and environmental parameters such as organic content, temperature, pH, and contact time.

Sampling and laboratory analysis were conducted to evaluate the formation potential of DBPs based upon the use of ozone, chlorine dioxide, and chlorine for disinfection. Additional information on the analysis of the three types of disinfection processing is presented in the *Disinfection Testing and Analysis Technical Memorandum*. This memorandum includes analysis of TTHM and HAA formation potential during disinfection.

According to the USEPA Stage 1 Disinfectant and Disinfection By-Product Rule (DBPR), TTHM includes the sum of the chloroform, bromodichloromethane, dibromochloromethane, and bromoform concentrations in drinking water. Toxicology studies have shown that TTHMs can be carcinogenic in laboratory animals.

HAA includes the sum of the monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid concentrations in drinking water. Studies have shown that HAA may cause adverse reproductive or developmental effects in laboratory animals.

Laboratory Results

The water used for sampling was collected on June 3, 2003 from the proposed location of the Buckman Direct Diversion Project Intake Structure on the Rio Grande. On June 5, 2003, bench scale testing of the raw water was completed using an optimized chemical dosing and mixing sequence that consisted of the addition of 1 mg/L potassium permanganate, 35 mg/L ferric chloride, 1.5 mg/L of cationic polymer, and 0.25 mg/L of non-ionic polymer. The water was coagulated and flocculated for 30 minutes and then an additional 30 minutes was allowed for settling. Settled water was decanted from the jar test containers from three duplicate test runs until 20 liters of settled water was collected for use in analysis. Settled water pH (6.9), turbidity (1.2 NTU), and temperature (23 degrees Celsius) were recorded. The water was sent to Colorado State University for disinfection testing.

Three discrete samples were collected from the 20-liter water sample and processed using ozone, chlorine dioxide, and chlorine, respectively, for disinfection. Tests were conducted at a temperature of 10 degrees Celsius and a pH of 6.9. After disinfection, chlorine was applied to each sample for simulated distribution system (SDS) testing. A 7-day detention time achieving a 0.5 mg/L chlorine residual at the end of the detention time was used as a conservative measure of DBP formation potential. For the chlorine and chlorine dioxide samples, 3 mg/L of chlorine was added for the SDS testing. For the ozone sample, a higher chlorine dose of 4.5 mg/L was necessary to achieve the 0.5 mg/L chlorine residual.

The three samples for the Buckman Direct Diversion Project were analyzed for TTHM and HAA concentrations. Results of the analytical laboratory analyses are presented in Table 1 below.

Table 1. Summary of Laboratory Analyses of Disinfection By-Product Concentrations

Primary Disinfection Process[1]	Total Trihalomethane Concentration (μg/L)	Total Haloacetic Acid Concentration (μg/L)
Chlorine (Sodium Hypochlorite) 1 mg/L, 20 min.	154	89
Ozone 1.25 mg/L, 10 min.	133	72
Chlorine Dioxide 0.75 mg/L, 20 min.	104	67
USEPA Standard[2]	**80**	**60**

[1]Primary disinfectant used followed by 7-day SDS test. Chlorine applied to all samples to achieve 0.5 mg/L chlorine residual.
[2]United States Environmental Protection Agency Stage 1 Disinfectant and Disinfection By-Product Rule Standard

Discussion of Results

All of collected samples exceed the DBPR Standards for both TTHM and HAA; however these results are for one sample only. The total organic carbon (TOC), a component of NOM, in the raw water was 5.6 mg/L. This TOC measurement was the highest of the three sampling periods. In addition, the 7-day SDS is a conservative measure and represents worst case conditions for this water. Actual DBP formation potential for this water will likely be different with full-scale processes including pre-sedimentation, enhanced coagulation, sedimentation, and filtration. The results of the analyses conclude that DBP formation was most significant, for both TTHM and HAA, using chlorine as a primary disinfectant. Chlorine was added as a secondary disinfectant in all three tests. Ozone produced 14 percent less TTHMs and 19 percent less HAAs than chlorine for this water sample. Chlorine dioxide produced 33 percent less TTHMs and 25 percent less HAAs than chlorine. These results indicate that primary disinfection with ozone or chlorine dioxide will decrease DBP formation for this water. Actual DBP values and percent reductions will likely be different at full-scale operation and will vary dependent on water conditions. The DBP values in this study should only be considered for general trends in DBP formation potential for the different disinfectants tested.

The results presented herein were conducted at a mid-range water temperature between cold winter conditions and warm summer conditions. DBP generation increases with water temperature. The effects of temperature on DBP formation are an important consideration and additional testing at other temperatures is recommended. During collection, the recorded raw water temperature was 20 degrees Celsius. The temperature of the water increased only slightly during the second round of testing. Therefore, the selection of the appropriate disinfectant and/or disinfection strategy must take into account this information. Minimization of DBPs is recommended at all times of the year.

This study only evaluated the relative DBP formation potential of three primary disinfectants. Overall system DBP compliance should consider different treatment methods (enhanced coagulation, filter absorbers, UV-disinfection, etc.) and the blending of all sources in the distribution system. These evaluations are beyond the scope of this study.

APPENDIX H
DISINFECTION TESTING AND ANALYSIS TECHNICAL MEMORANDUM

CDM

Technical Memorandum

MRC WTP Water Quality Studies and Evaluations Project Disinfection Testing and Analysis

March 18, 2005

Summary

Purpose

The purpose of this memorandum is to summarize the projected performance of three different disinfectants for the Buckman Direct Diversion Project drinking water system primary and/or secondary disinfection process. Conventional disinfection using ozone, chlorine dioxide, and chlorine (as sodium hypochlorite), respectively, were analyzed for this study.

Conclusions

In drinking water treatment, chemical disinfectants added to the water decay over time. As presented in this memorandum, all three selected disinfectants exhibited this behavior. The analyses show that ozone decays more rapidly than chlorine dioxide or chlorine. Initial demand for ozone was also greater than the demands for chlorine dioxide and chlorine as the disinfectant.

Selection of a disinfectant will need to be made based on balancing regulatory requirements, minimizing disinfection by-products, capital and operating costs, operator preferences, and safety and health risks.

Background

Applying chemical disinfectants to drinking water in the United States has successfully controlled the transmission of disease-causing organisms, or pathogens, through drinking water supply systems. New technologies, physical and chemical processes, are continually being used to control pathogens during disinfection processes. Disinfection approaches must be designed and operated to protect the public health from the chronic and acute risks while conforming to the United States Environmental Protection Agency's (USEPA) Safe Drinking Water Act regulations.

Additionally, disinfectants are also used as oxidants in drinking water treatment to remove taste and odors, prevent biological growth and, in some cases, enhance the removal of organics. However, use of disinfectants can compound the problem of disinfection by-product (DBP) formation, since DBP generation varies with the different types of disinfectants/oxidants. Additional information on the DBP formation for the Buckman Direct Diversion Project is presented in the *Disinfection By-Product Study Technical Memorandum*.

Disinfectants

For the disinfection testing and analysis, three separate disinfectants were used: ozone, chlorine dioxide, and chlorine (as hypochlorite). Drinking water systems in the United States may use other disinfectants, such as chlorine gas or ultraviolet light (UV). Chlorine as a gas was not used in this study and will not be evaluated due to the inherent and perceived safety hazards and regulatory compliance requirements which accompany this chemical. UV disinfection testing requires laboratory, pilot, or full-scale analysis and is highly dependent on water quality; therefore it was not tested at this stage. UV will be evaluated in the report as a possible disinfection process. Chloramines may be used to provide distribution system residual disinfection (secondary disinfection) to minimize DBP formation; however, chlorine is typically used. The three disinfectants selected for this study are readily available in the United States and vary in expense.

Ozone is the most powerful disinfectant available. Typically, ozone is continually injected into the water as a gas (O_3) and requires specific structures and equipment for on-site generation, diffusion and transfer, detention, and off-gassing destruction. Ozone generation equipment must operate near full capacity the majority of the time. This can lead to higher capital and operating costs for drinking water treatment systems. Although ozone is one of the most expensive disinfection methods, it is becoming increasing prevalent in water treatment systems in the United States and is one of the most commonly used methods in Europe. Ozone is a strong oxidant; it greatly improves the aesthetic quality of water (color, taste, and odor) and it enhances coagulation. The disadvantages to using ozone include the need for on-site generation, generation or supply of a feed gas (liquid oxygen), and the hazardous nature of ozone. Also, ozone systems are significantly more complex to operate and maintain.

Chlorine dioxide is another powerful disinfectant, yet not as powerful as ozone. Typically, chlorine dioxide is injected into the water as a liquid (ClO_2) and requires equipment for on-site generation and injection. Chlorite and chlorate formation may occur when using chlorine dioxide, which may result in additional water processing and higher capital and operating costs for drinking water treatment systems. A few advantages of using chlorine dioxide as the disinfectant include its abilities to reduce biological growth, improve filtration performance, destroy certain odor causing compounds, and meet the required disinfection credit. The disadvantages to using chlorine dioxide include on-site generation requires the use of two or three chemicals in the generation process; chlorite and chlorate monitoring, and covering of basins, since sunlight exposure reduces the residual.

Chlorine, as hypochlorite, is one of the least expensive disinfectants available. Typically, chlorine is continually injected into the water as a weak-solution liquid (Cl_2) and requires equipment for on-site generation and injection. DBP formation may occur when using chlorine, which may result in additional water processing and higher capital and operating costs for drinking water treatment systems. Despite the DBP formation potential, chlorine (as gaseous chlorine or sodium hypochlorite) disinfection is one of the most commonly used methods in the United States.

A few advantages of using chlorine as the disinfectant include its effectiveness at killing bacteria, its ability to oxidize iron and manganese, its success in some taste, odor, and color removal, and relatively low cost. The disadvantages to using chlorine include the potential to form DBPs and potential to produce undesirable tastes and odors. The safety and health regulations pertaining to the handling of chlorine, especially as a gas, are becoming increasingly stringent.

New studies indicate that a small dose of chlorine dioxide in conjunction with chlorine will reduce the chlorine dose and significantly reduce DBPs.

Demand and Decay Analysis

Demand and decay data are typically used in conceptual and preliminary drinking water treatment system design. The ranges of dose requirements and the extent of disinfectant residuals are used to aid in process selection, chemical selection, and equipment selection. Not only does this information help determine capital costs for treatment systems, it provides estimates for maintenance and operating costs.

Demand and decay tests were performed to determine the dose requirement and the extent of the residual disinfectant for each chemical. After a disinfectant is added to the water, it will decay. This characteristic is important because as the disinfectant concentration decreases, the disinfection effectiveness decreases. Disinfection kinetics and/or modeling are typically used to determine the extent of decay. The same methods are used to determine disinfectant demand, which is based upon the applied dosage.

The decay was calculated based on first-order decay kinetics:

$$\mathbf{C(t) = C_i\, e^{\wedge(-k_d * t)}}$$

where: $C(t)$ is the disinfectant residual (in mg/L);

C_i is the initial disinfectant dose (in mg/L);

k_d is the decay coefficient (in min^{-1}); and

t is the reaction time (in min).

The disinfectant residual [C(t)] was determined using laboratory testing methods. Using discrete time intervals (0.5 minute, 1 minute, etc.) the residual disinfectant concentration was recorded for use in the demand and decay calculations. Using these parameters, the decay coefficient was calculated for the three different disinfectants. Analysis of the demand and decay calculations is presented in the following section.

Laboratory Results

The water used for sampling was collected on June 3, 2003 from the proposed location of the Buckman Direct Diversion Project Intake Structure on the Rio Grande. On June 5, 2003, bench scale testing of the raw water was completed using an optimized chemical dosing and mixing sequence that consisted of the addition of 1 mg/L potassium permanganate, 35 mg/L ferric chloride, 1.5 mg/L of cationic polymer, and 0.25 mg/L of non-ionic polymer. The water was coagulated and flocculated for 30 minutes and then an additional 30 minutes was allowed for settling. Settled water was decanted from the jar test containers from three duplicate test runs until 20 liters of settled water was collected for use in analysis. Settled water pH (6.9), turbidity (1.2 NTU), and temperature (23 degrees Celsius) were recorded. The water was sent to Colorado State University for disinfection testing.

Three discrete samples were collected from the 20-liter water sample and processed using ozone, chlorine dioxide, and chlorine, respectively, for disinfection. Five samples were tested using ozone as the disinfectant, three were tested using chlorine dioxide as the disinfectant, and three were tested using chlorine as the disinfectant.

For each test, the initial dosage was varied, so the residual disinfectant concentration could be recorded using discrete time intervals (0.5 minute, 1 minute, etc.). The initial dose for each test run and selected residual disinfectant concentrations are presented in Table 1. Complete data tables, including residual disinfectant concentrations for all time intervals, are included in Appendix A.

Table 1. Summary of Initial Dosage and Residual Concentrations for Disinfection Test Runs

Disinfectant	Test Run	Initial Dose Concentration (mg/L)	Residual Concentration (mg/L) at 1.0 min	Residual Concentration (mg/L) at 10.0 min[1]
Ozone	1	1.50	0.74	0.16
	2	1.50	0.82	0.17
	3	2.00	1.27	0.46
	4	1.00	0.42	0.03
	5	1.00	0.40	0.01
Chlorine Dioxide	1	0.50	0.27	0.16
	2	0.75	0.45	0.35
	3	1.00	0.63	0.50
Chlorine (as Hypochlorite)	1	0.60	0.31	0.14
	2	1.00	0.66	0.40
	3	1.50	1.09	0.75

[1]Residual Concentrations at 10.0 minutes for chlorine were calculated using the trendline equation for each Test Run (refer to Appendix B).

The results indicate the thirty-second ozone demand ranged from 0.49 to 0.66 mg/L. The one-minute chlorine dioxide demand ranged from 0.23 to 0.37 mg/L and the one-minute chlorine demand ranged from 0.29 to 0.41 mg/L. The following figures present represent disinfectant decay profiles from the bench scale testing. The disinfectant residual is plotted versus reaction time (t) in minutes where the symbols on the graphs represent actual data points.

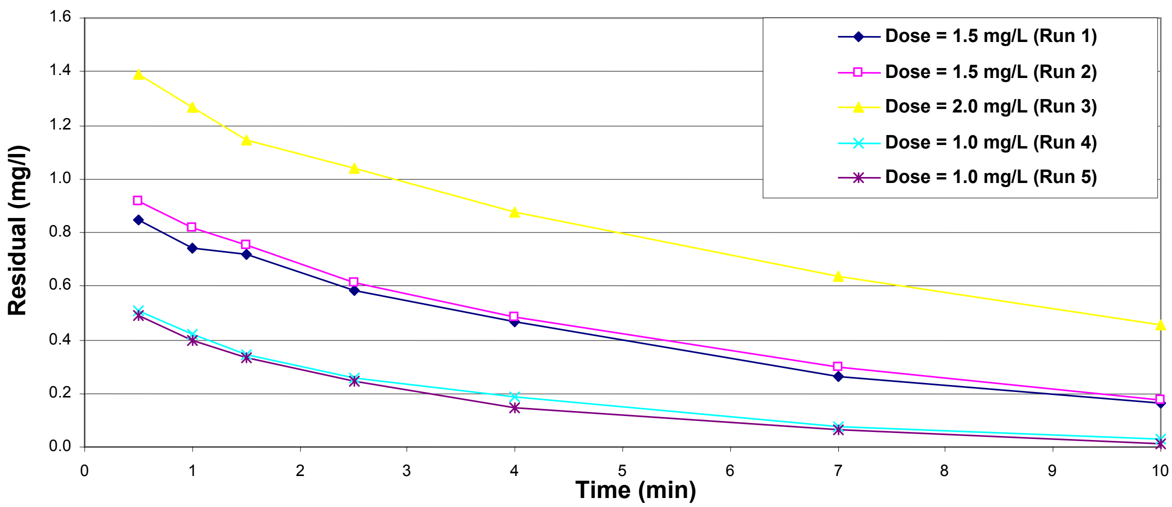


Figure 1. Buckman Direct Diversion Project
Disinfection Using Ozone - Residual vs. Time
(Temp = 10°C, pH = 6.9, Ozone Demand = 0.49 - 0.66 mg/L)

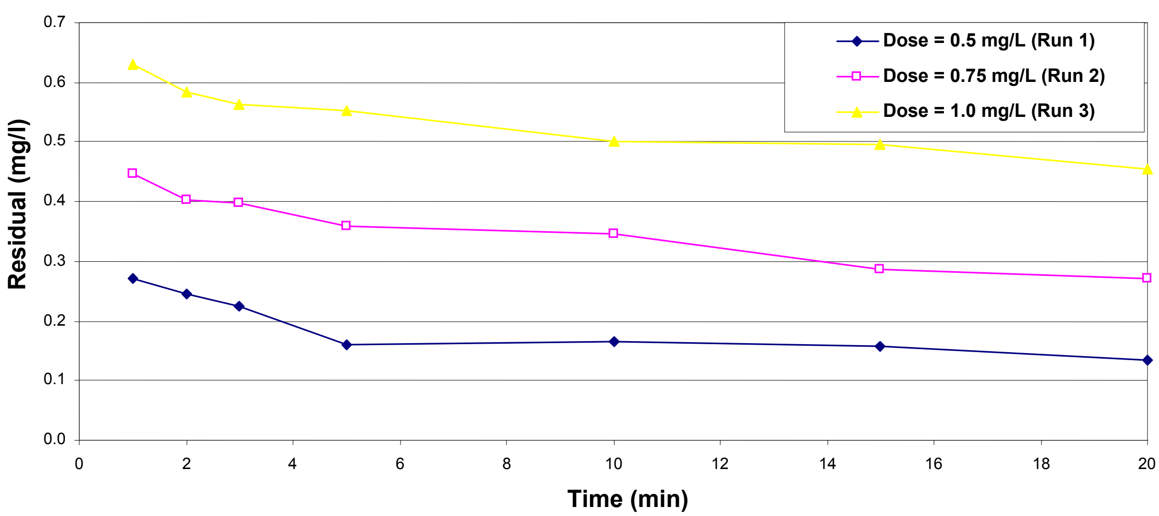


Figure 2. Buckman Direct Diversion Project
Disinfection Using Chlorine Dioxide - Residual vs. Time
(Temp = 10°C, pH = 6.9, Chlorine Dioxide Demand = 0.23 - 0.37 mg/L)

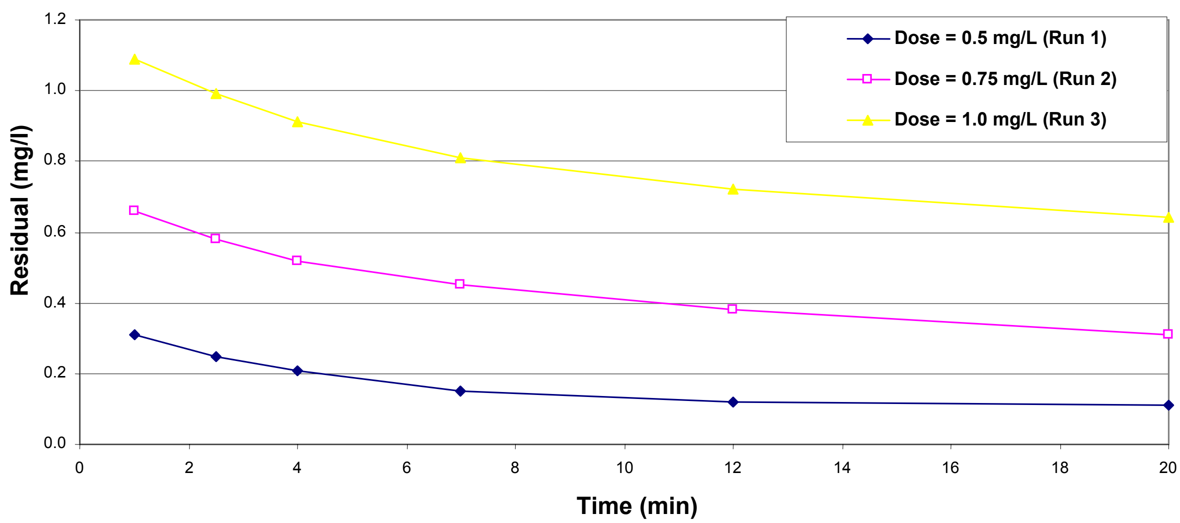


Figure 3. Buckman Direct Diversion Project
Disinfection Using Chlorine (as Hypochlorite) - Residual vs. Time
(Temp = 10°C, pH = 6.9, Chlorine Demand = 0.29 - 0.41 mg/L)

In drinking water treatment, any chemical disinfectant added to the water will decay over time. Ozone decayed more rapidly than chlorine dioxide and chlorine (as hypochlorite) in this analysis. The demand for ozone as the disinfectant was also greater than the demands for chlorine dioxide and chlorine. The demand/decay data and assumed detention times will be used to estimate required doses for disinfection credit requirements.

These factors, along with capital and operating costs, must be taken into account when selecting the appropriate disinfectant for the Buckman Direct Diversion Project. Increasingly stringent regulations and safety and health risks pertaining to the handling of chemical disinfectants must also be considered during the selection of the appropriate disinfectant and/or disinfection strategy.

Appendix A
Ozone, Chlorine Dioxide, and Chlorine Data Tables

Ozone Residual Calculations - Buckman Direct Diversion Project

Constant	0.42

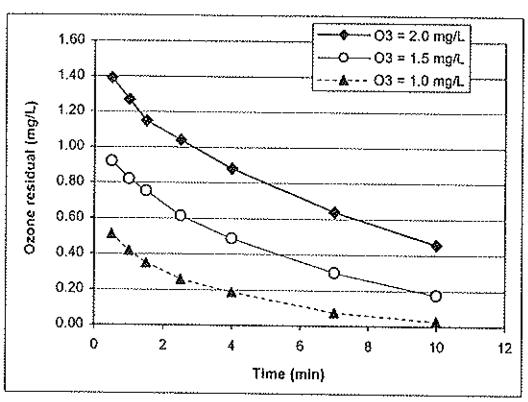
Temperature 9.0										
Stock/Time	Sample	Reagent	A_{sample}	Fraction	A_{blank}	V_{tot}	Path L	DO3	CheckA_{blank}	%Vary
--	ml	ml			cm-1	ml	cm	mg/L	cm-1	
Run No 1	Stock: 1		Slope: 23.601		Intercept:	-0.0006		Dose = 1.5 mg/L		
Stock	10	32	1.960	0.7619	17.98	42	5	32.04		
0.5	20	3	1.342	0.1304	2.884	23	5	0.84	3.078	-6.30%
1	20	3	1.528	0.1304	2.884	23	5	0.74	3.078	-6.30%
1.5	20	2	0.718	0.0909	2.089	22	5	0.72	2.145	-2.61%
2.5	20	2	0.974	0.0909	2.089	22	5	0.58	2.145	-2.61%
4	20	2	1.193	0.0909	2.089	22	5	0.47	2.145	-2.61%
7	20	2	1.583	0.0909	2.089	22	5	0.27	2.145	-2.61%
10	20	2	1.782	0.0909	2.089	22	5	0.16	2.145	-2.61%

Run No 2	Stock: 1		Slope: 23.601		Intercept:	-0.0006		Dose = 1.5 mg/L		
Stock	10	35	1.722	0.7778	18.36	45	5	35.64		
0.5	20	2	0.336	0.0909	2.089	22	5	0.92	2.145	-2.61%
1	20	2	0.526	0.0909	2.089	22	5	0.82	2.145	-2.61%
1.5	20	2	0.654	0.0909	2.089	22	5	0.75	2.145	-2.61%
2.5	20	2	0.920	0.0909	2.089	22	5	0.61	2.145	-2.61%
4	20	2	1.161	0.0909	2.089	22	5	0.49	2.145	-2.61%
7	20	2	1.524	0.0909	2.089	22	5	0.30	2.145	-2.61%
10	20	2	1.758	0.0909	2.089	22	5	0.17	2.145	-2.61%

Run No 3	Stock: 1		Slope: 23.601		Intercept:	-0.0006		Dose = 2.0 mg/L		
Stock	10	32	2.926	0.7619	17.98	42	5	30.11		
0.5	20	3	0.346	0.1304	2.884	23	5	1.39	3.078	-6.30%
1	20	3	0.571	0.1304	2.884	23	5	1.27	3.078	-6.30%
1.5	20	3	0.793	0.1304	2.884	23	5	1.15	3.078	-6.30%
2.5	20	2	0.104	0.0909	2.089	22	5	1.04	2.145	-2.61%
4	20	2	0.413	0.0909	2.089	22	5	0.88	2.145	-2.61%
7	20	2	0.874	0.0909	2.089	22	5	0.64	2.145	-2.61%
10	20	2	1.219	0.0909	2.089	22	5	0.46	2.145	-2.61%

Run No 4	Stock: 1		Slope: 23.601		Intercept:	-0.0006		Dose = 1.0 mg/L		
Stock	10	25	1.411	0.7143	16.86	35	5	25.74		
0.5	20	2	1.114	0.0909	2.089	22	5	0.51	2.145	-2.61%
1	20	2	1.291	0.0909	2.089	22	5	0.42	2.145	-2.61%
1.5	20	2	1.427	0.0909	2.089	22	5	0.35	2.145	-2.61%
2.5	20	2	1.600	0.0909	2.089	22	5	0.26	2.145	-2.61%
4	20	2	1.734	0.0909	2.089	22	5	0.19	2.145	-2.61%
7	20	2	1.946	0.0909	2.089	22	5	0.07	2.145	-2.61%
10	20	2	2.038	0.0909	2.089	22	5	0.03	2.145	-2.61%

Run No 5	Stock: 1		Slope: 23.601		Intercept:	-0.0006		Dose = 1.0 mg/L		
Stock	10	25	1.411	0.7143	16.86	35	5	25.74		
0.5	20	2	1.148	0.0909	2.089	22	5	0.49	2.145	-2.61%
1	20	2	1.333	0.0909	2.089	22	5	0.40	2.145	-2.61%
1.5	20	2	1.456	0.0909	2.089	22	5	0.33	2.145	-2.61%
2.5	20	2	1.618	0.0909	2.089	22	5	0.25	2.145	-2.61%
4	20	2	1.812	0.0909	2.089	22	5	0.15	2.145	-2.61%
7	20	2	1.966	0.0909	2.089	22	5	0.06	2.145	-2.61%
10	20	2	2.068	0.0909	2.089	22	5	0.01	2.145	-2.61%

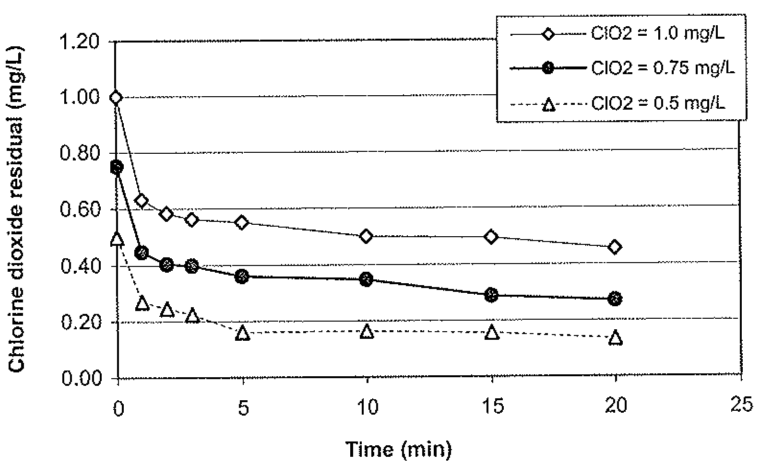


O:\1257-32934 Santa Fe Water Supply Plan\Water Quality Testing\Data\[demand-decay data May.xls]ClO2 & Cl2 Demand

Chlorine Dioxide Residual Calculations - Buckman Direct Diversion Project

Raw zero
2.284

Time (min)	ClO2 = 0.5 abs$_{614}$ (5cm^{-1})	ClO2 = 0.5 ClO$_2$ (mg/L)	ClO2 = 0.75 abs$_{614}$ (5cm^{-1})	ClO2 = 0.75 ClO$_2$ (mg/L)	ClO2 = 1.0 abs$_{614}$ (5cm^{-1})	ClO2 = 1.0 ClO$_2$ (mg/L)
0		0.50		0.75		1.00
1	1.942	0.27	1.719	0.45	1.485	0.63
2	1.972	0.25	1.773	0.40	1.545	0.58
3	2.000	0.22	1.78	0.40	1.571	0.56
5	2.081	0.16	1.828	0.36	1.586	0.55
10	2.076	0.16	1.845	0.35	1.651	0.50
15	2.086	0.16	1.921	0.29	1.658	0.49
20	2.114	0.13	1.942	0.27	1.709	0.45
CT@20 min				**5.4**		**9.1**



Dose mg/L	k min^{-1}	Co mg/L	Time min	ClO2 mg/L	CT mg/L*min
			0	1.3	0
1.3	-0.025	0.76	1	0.74	0.74
1.3	-0.025	0.76	2	0.72	1.45
1.3	-0.025	0.76	3	0.71	2.12
1.3	-0.025	0.76	5	0.67	3.36
1.3	-0.025	0.76	10	0.59	5.95
1.3	-0.025	0.76	15	0.53	7.89

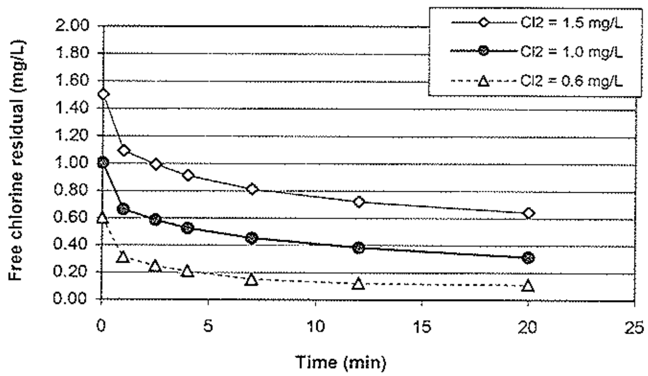
O:\1257-32934 Santa Fe Water Supply Plan\Water Quality Testing\Data\[demand-decay data May.xls]ClO2 & Cl2 Demand

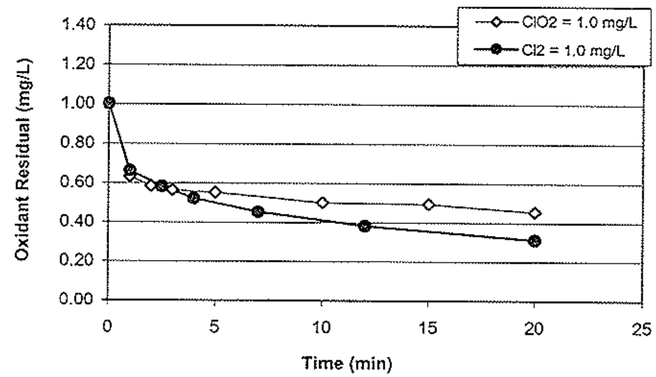
Chlorine Residual Calculations - Buckman Direct Diversion Project

Raw zero
2.284

Chlorine as Hypochlorite

	Cl2 = 0.6	Cl2 = 1.0	Cl2 = 1.5
Time (min)	**Cl_2** (mg/L)	**Cl_2** (mg/L)	**Cl_2** (mg/L)
0	0.60	1.00	1.50
1	0.31	0.66	1.09
2.5	0.25	0.58	0.99
4	0.21	0.52	0.91
7	0.15	0.45	0.81
12	0.12	0.38	0.72
20	0.11	0.31	0.64
		1.80	1.80





Dose mg/L	k min^{-1}	Co mg/L	Time min	ClO2 mg/L	CT mg/L*min
			0	1.3	0
1.3	-0.025	0.76	1	0.74	0.74
1.3	-0.025	0.76	2	0.72	1.45
1.3	-0.025	0.76	3	0.71	2.12
1.3	-0.025	0.76	5	0.67	3.36
1.3	-0.025	0.76	10	0.59	5.95
1.3	-0.025	0.76	15	0.53	7.89

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Appendix B
Demand and Decay Calculations

Demand and Decay Calculations - Buckman Direct Diversion Project

Ozone

Formula:
C(T) = Ci * e^(-Kd * T)
Kd = -{[Ln (C(T) / Ci)] / T}

Variables:
C(T) = Ozone Residual (mg/L)
Ci = Initial Dose of Ozone (mg/L)
Kd = Decay Coefficient (min^(-1))
T = Time (min)

Ozone Demand Value:
(at Ci minus C(T) at T=0.5)

Run No. 1

Dosage (mg/L) (Ci)	Time (min) (T)	Residual (mg/L) (C(T))	Decay Coefficient (min^(-1)) (Kd)
	Stock	32.04	
1.5	0.5	0.84	1.1491
1.5	1.0	0.74	0.7031
1.5	1.5	0.72	0.4910
1.5	2.5	0.58	0.3773
1.5	4.0	0.47	0.2905
1.5	7.0	0.27	0.2476
1.5	10.0	0.16	0.2233
Ozone Demand (mg/L) =			0.66

Run No. 2

Dosage (mg/L) (Ci)	Time (min) (T)	Residual (mg/L) (C(T))	Decay Coefficient (min^(-1)) (Kd)
	Stock	35.64	
1.5	0.5	0.92	0.9815
1.5	1.0	0.82	0.6055
1.5	1.5	0.75	0.4606
1.5	2.5	0.61	0.3584
1.5	4.0	0.49	0.2817
1.5	7.0	0.30	0.2319
1.5	10.0	0.17	0.2158
Ozone Demand (mg/L) =			0.58

Run No. 3

Dosage (mg/L) (Ci)	Time (min) (T)	Residual (mg/L) (C(T))	Decay Coefficient (min^(-1)) (Kd)
	Stock	30.11	
2.0	0.5	1.39	0.7279
2.0	1.0	1.27	0.4568
2.0	1.5	1.15	0.3718
2.0	2.5	1.04	0.2617
2.0	4.0	0.88	0.2058
2.0	7.0	0.64	0.1636
2.0	10.0	0.46	0.1479
Ozone Demand (mg/L) =			0.61

Run No. 4

Dosage (mg/L) (Ci)	Time (min) (T)	Residual (mg/L) (C(T))	Decay Coefficient (min^(-1)) (Kd)
	Stock	25.74	
1.0	0.5	0.51	1.3439
1.0	1.0	0.42	0.8723
1.0	1.5	0.35	0.7061
1.0	2.5	0.26	0.5448
1.0	4.0	0.19	0.4206
1.0	7.0	0.07	0.3722
1.0	10.0	0.03	0.3623
Ozone Demand (mg/L) =			0.49

Run No. 5

Dosage (mg/L) (Ci)	Time (min) (T)	Residual (mg/L) (C(T))	Decay Coefficient (min^(-1)) (Kd)
	Stock	25.74	
1.0	0.5	0.49	1.4149
1.0	1.0	0.40	0.9263
1.0	1.5	0.33	0.7359
1.0	2.5	0.25	0.5598
1.0	4.0	0.15	0.4826
1.0	7.0	0.06	0.3917
1.0	10	0.01	0.4510
Ozone Demand (mg/L) =			0.51

Chlorine Dioxide

Formula:
C(T) = Ci * e^(-Kd * T)
Kd = -{[Ln (C(T) / Ci)] / T}

Variables:
C(T) = ClO2 Residual (mg/L)
Ci = Initial Dose of ClO2 (mg/L)
Kd = Decay Coefficient (min^(-1))
T = Time (min)

ClO2 Demand Value:
(at Ci minus C(T) at T=0.5)

Run No. 1

Dosage (mg/L) (Ci)	Time (min) (T)	Residual (mg/L) (C(T))	Decay Coefficient (min^(-1)) (Kd)
	Stock	0.50	
0.5	1	0.27	0.6153
0.5	2	0.25	0.3535
0.5	3	0.22	0.2670
0.5	5	0.16	0.2274
0.5	10	0.16	0.1113
0.5	15	0.16	0.0775
0.5	20	0.13	0.0657
Chlorine Dioxide Demand (mg/L)			0.20

Run No. 2

Dosage (mg/L) (Ci)	Time (min) (T)	Residual (mg/L) (C(T))	Decay Coefficient (min^(-1)) (Kd)
	Stock	0.75	
0.75	1	0.45	0.5187
0.75	2	0.40	0.3096
0.75	3	0.40	0.2110
0.75	5	0.36	0.1466
0.75	10	0.35	0.0771
0.75	15	0.29	0.0641
0.75	20	0.27	0.0510
Chlorine Dioxide Demand (mg/L)			0.26

Run No. 3

Dosage (mg/L) (Ci)	Time (min) (T)	Residual (mg/L) (C(T))	Decay Coefficient (min^(-1)) (Kd)
	Stock	1.00	
1.0	1	0.63	0.4599
1.0	2	0.58	0.2690
1.0	3	0.56	0.1912
1.0	5	0.55	0.1190
1.0	10	0.50	0.0693
1.0	15	0.49	0.0469
1.0	20	0.45	0.0394
Chlorine Dioxide Demand (mg/L)			0.33

Chlorine (as Hypochlorite)

Formula:
C(T) = Ci * e^(-Kd * T)
Kd = -{[Ln (C(T) / Ci)] / T}

Variables:
C(T) = Chlorine Residual (mg/L)
Ci = Initial Dose of Chlorine (mg/L)
Kd = Decay Coefficient (min^(-1))
T = Time (min)

Chlorine Demand Value:
(at Ci minus C(T) at T=0.5)

Run No. 1

Dosage (mg/L) (Ci)	Time (min) (T)	Residual (mg/L) (C(T))	Decay Coefficient (min^(-1)) (Kd)
	Stock	0.60	
0.6	1.0	0.31	0.6604
0.6	2.5	0.25	0.3502
0.6	4.0	0.21	0.2625
0.6	7.0	0.15	0.1980
0.6	12.0	0.12	0.1341
0.6	20.0	0.11	0.0848
Chlorine Demand (mg/L) =			0.24

Run No. 2

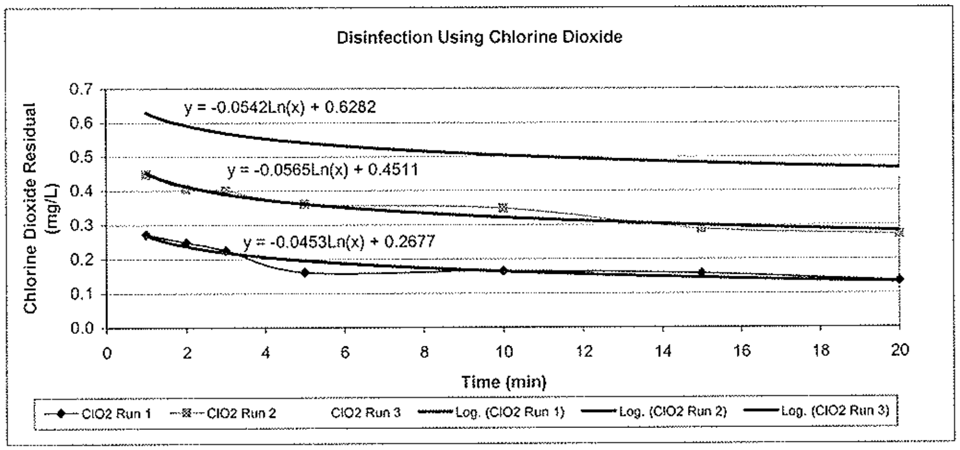
Dosage (mg/L) (Ci)	Time (min) (T)	Residual (mg/L) (C(T))	Decay Coefficient (min^(-1)) (Kd)
	Stock	1.00	
1.0	1.0	0.66	0.4155
1.0	2.5	0.58	0.2179
1.0	4.0	0.52	0.1635
1.0	7.0	0.45	0.1141
1.0	12.0	0.38	0.0806
1.0	20.0	0.31	0.0586
Chlorine Demand (mg/L) =			0.24

Run No. 3

Dosage (mg/L) (Ci)	Time (min) (T)	Residual (mg/L) (C(T))	Decay Coefficient (min^(-1)) (Kd)
	Stock	1.50	
1.5	1.0	1.09	0.3193
1.5	2.5	0.99	0.1662
1.5	4.0	0.91	0.1249
1.5	7.0	0.81	0.0880
1.5	12.0	0.72	0.0612
1.5	20.0	0.64	0.0426
Chlorine Demand (mg/L) =			0.28

Demand Figures and Calculations - Buckman Direct Diversion Project

Chlorine Dioxide

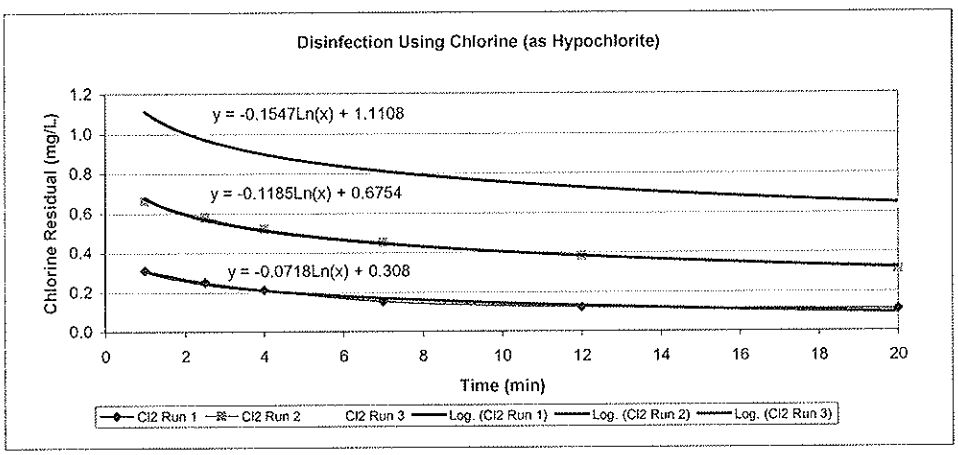


Run 1 - Equation of Line:	C(T) = -0.0453 * Ln (T) + 0.2677
Run 2 - Equation of Line:	C(T) = -0.0565 * Ln (T) + 0.4511
Run 3 - Equation of Line:	C(T) = -0.0542 * Ln (T) + 0.6282

Calculate Chlorine Dioxide Demand (at Ci minus C(T) at T=0.5 min)

Run 1 C(0.5 min) =	0.2991	(mg/L)
Run 1 Demand =	0.2009	(mg/L)
Run 2 C(0.5 min) =	0.4903	(mg/L)
Run 2 Demand =	0.2597	(mg/L)
Run 3 C(0.5 min) =	0.6658	(mg/L)
Run 3 Demand =	0.3342	(mg/L)

Chlorine



Run 1 - Equation of Line:	C(T) = -0.0718 * Ln (T) + 0.308
Run 2 - Equation of Line:	C(T) = -0.1185 * Ln (T) + 0.6754
Run 3 - Equation of Line:	C(T) = -0.1547 * Ln (T) + 1.1108

Calculate Chlorine Demand (at Ci minus C(T) at T=0.5 min)

Run 1 C(0.5 min) =	0.3578	(mg/L)
Run 1 Demand =	0.2422	(mg/L)
Run 2 C(0.5 min) =	0.7575	(mg/L)
Run 2 Demand =	0.2425	(mg/L)
Run 3 C(0.5 min) =	1.2180	(mg/L)
Run 3 Demand =	0.2820	(mg/L)

Calculate Chlorine Residual (mg/L) at T=10.0 min

Run 1 C(10.0 min) =	0.1427	(mg/L)
Run 2 C(10.0 min) =	0.4025	(mg/L)
Run 3 C(10.0 min) =	0.7546	(mg/L)

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APPENDIX I
CORROSION AND BLENDING STUDY TECHNICAL MEMORANDUM

CDM

Technical Memorandum

MRC WTP Water Quality Studies and Evaluations Project Corrosion and Blending Study

March 18 2005

Summary

Purpose

The purpose of this memorandum is to summarize the needs for corrosion control and pH adjustment necessary for blending and/or distribution of the treated Rio Grande water with the Buckman Well Field water for the Buckman Direct Diversion Project.

Conclusions

In drinking water treatment, water quality characteristics and chemical dosage requirements must periodically be monitored to prevent excessive corrosion and scaling in piping systems. For this evaluation, Rio Grande water and Buckman Well Field waters (Wells 1 through 13) were analyzed using specific water quality modeling software. Results of the analyses conclude that Rio Grande water, if properly conditioned, will be no more or no less problematic than the Buckman Well Field water. Periodic evaluation and monitoring of water quality characteristics and chemical dosages should be performed during operation of the MRC Water Treatment Plant to prevent excessive corrosion and/or scaling conditions when blended with other water sources.

Additional testing of the MRC WTP water with Canyon Road WTP water and City well water is recommended as it was outside the scope of this study. A pipe loop study or corrosion coupon testing of all water sources prior to operation of the MRC WTP would be beneficial to fully evaluate compliance with the Lead and Copper Rule.

Background

In 1991, the United States Environmental Protection Agency (USEPA) promulgated the Lead and Copper Rule (LCR). The rule reduced the acceptable amount of lead and copper in drinking water as a result of corrosion of metal water service pipes and fittings. Lead and copper exposure through public drinking water supplies may cause illness or cause adverse effects to human health. Certain water quality factors, such as pH and alkalinity, greatly affect water's ability to leach lead and copper from household piping.

Corrosion is simply defined as the process of corroding, or degradation of materials such as metal and concrete. All water is corrosive to some degree. However, under certain conditions, some water sources are more corrosive than others and can be destructive to water supply infrastructure. Conversely, some water sources create scale, or a rigid build-up of minerals and particles, within distribution pipes. The formation of scale within piping systems can actually provide a protective barrier and prolong the life of the piping system. However, alternating between corrosive and scaling water qualities is highly undesirable and can result in significant water quality problems.

There are several factors that influence water corrosivity, as described in Table 1. The ease or difficulty of controlling each factor is also presented in this table.

Table 1. Summary of Factors which Affect Corrosion in Water Systems

Factor	Definition / Corrosion Influence	Control Method
Dissolved Oxygen (DO)	Defines the concentration of oxygen gas dissolved in water. Corrosivity increases with DO.	Very difficult to control in open systems.
pH	Typical scale: 0-14. Defines the amount of free acidity in water. Log scale of acid concentration of one unit decrease corresponds to a 10-fold increase in acid concentration. Normal range in groundwater and surface water: 6.5-8.5. Usually, higher pH means higher alkalinity. Corrosivity increases with decreasing pH.	Relatively easy to control in water with low to moderate alkalinity. Requires the addition of basic or acidic chemicals, such as soda ash or sulfuric acid.
Total Dissolved Solids (TDS)	Refers to the amount of dissolved minerals in water. Ninety percent or more of TDS in natural waters includes the following elements: sodium, calcium, magnesium, potassium, chloride, sulfate, and carbonate. These elements are from salt, gypsum, calcite, and other minerals. In general, corrosivity increases with TDS, depending on alkalinity.	Moderately easy to very difficult to change. Dilution is easy. Removal by filtration is moderately difficult and expensive.
Alkalinity	Reported as milligrams per liter (mg/L) as calcium carbonate ($CaCO_3$). Refers to the concentration of carbonates and bicarbonates present in water. In general, corrosivity decreases with increasing alkalinity. However, excessive $CaCO_3$ scale can clog pipes.	Moderately easy to change. Requires the addition of basic or acidic chemicals, such as soda ash or sulfuric acid.
Temperature	Varies with season and location. Corrosivity can increase or decrease, depending on alkalinity and temperature range. Higher temperatures increase metal oxidation rates, but they also increase scale formation by calcite precipitation.	Cannot be controlled. Groundwater temperature is more constant (typically 20-30 °C).
Type of Pipe	In general, metal pipes corrode and plastic pipes do not. Materials most susceptible to corrosion are galvanized iron, galvanized steel, concrete, aluminum, and iron. Materials least susceptible to corrosion are plastic, stainless steel, and copper. Zinc metal corrodes much faster than iron, which helps protect iron from corrosion in galvanized iron pipes.	Controllable in new homes. Use of plastic pipes typically restricted by building codes. Can be expensive to retrofit. Use of corrosion inhibitors, such as polyphosphate can be used for control within the distribution system.
Water Velocity	Corrosivity may increase at high velocity due to turbulence that helps DO react faster with the metal surface. However, at high velocity, faster scale formation of $CaCO_3$ (a corrosion inhibitor) may also occur.	May be controllable through pipe design changes and use of low water use appliances, faucets, shower heads, etc.
Hardness	Hardness refers to the concentration of calcium and magnesium ions, but is usually reported in mg/L of $CaCO_3$. Water hardness is linked to scale formation and the reduced cleaning efficiency of soaps. Hardness is linked to scale formation; therefore, hard water is less corrosive than soft water within pipelines.	Control through water softening and salt removal techniques.

Source: Arizona Water Resources Research Center, *Water in the Tucson Area: Seeking Sustainability (Chapter 6).*

In many areas of the United States, particularly in the southwest, water supplies are obtained from multiple sources, including surface water and ground water. Once the water sources are blended together, the consideration of water quality becomes increasingly important with respect to corrosion or scaling minimization in the drinking water system.

Experiences of blending water sources are presented in the following section. Pertinent to the Buckman Direct Diversion Project, these examples are primarily experiences in the southwestern United States.

Experiences with Blending Waters

The following paragraphs discuss the strategies used by different agencies to inhibit corrosion successfully or not so successfully, in one case.

Metropolitan Water District of Southern California (MWD) and Member Agencies

MWD treats and delivers drinking water to about 15 million people in Southern California. Their two primary drinking water sources are the California State Project and from the Colorado River. Water from the State Project has moderate levels of alkalinity, TDS, and hardness. The Colorado River is high in TDS with moderate to high levels of alkalinity and hardness. To control corrosion of the treated water, MWD adds a chemical to increase the finished water pH. This practice has allowed MWD and its member agencies to successfully meet the LCR regulations.

San Francisco (California) Public Utilities Commission (SFPUC)

This utility serves water to as many as 2.5 million people in the San Francisco Bay Area. Some of their wholesale customers blend the water received from SFPUC with local groundwater or surface water supplies. SFPUC also has two distinctly different water sources in terms of quality. The Hetch Hetchy source originates in the Sierra Mountain range and has extremely low alkalinity, hardness, and TDS (i.e., less than 20 mg/L). The Hetch Hetchy source is very aggressive and needs to be treated by increasing the pH with lime in the transmission system to avoid damage to concrete lined pipelines. The other source is a set of local impounded watersheds. This source has water with moderate to high levels of alkalinity, pH, TDS, and hardness. The only corrosion control strategy used for the treated water is pH adjustment. In fact, SFPUC has found that keeping the pH consistently above 8.5 avoids formation of red water caused by iron corrosion from their unlined cast iron pipelines.

Tucson (Arizona) Water

In the early 1990s, Tucson Water introduced a new treated water source from the Colorado River into their distribution system. This caused the formation of red water, presumably from iron corrosion of unlined mains and service connections. A study by CDM in 1995 found that Tucson Water applied pH adjustment to the treated water *intermittently* during the 2 years of operations. Pipe loop studies reviewing different corrosion control strategies concluded that the parameter with the strongest impact on corrosion is pH.

The study also determined that consistently adjusting and maintaining pH at a certain level could be used to successfully control corrosion in this specific distribution system.

City of Phoenix, Arizona
Phoenix blends water from the Colorado River, local groundwater sources, and from the Salt River Project. They control corrosion by adjusting pH.

Santa Clara Valley Water District (SCVWD - San Jose, California area) and Wholesale Customers
SCVWD owns three water treatment plants and wholesales treated water to several municipalities and private companies in the South Bay area of the San Francisco Bay. This treated water is blended with several other sources, including water from SFPUC and local groundwater. For several years, SCVWD used a phosphate-based inhibitor to control corrosion. Because of the time required to passivate pipelines with an inhibitor, SCVWD considered using pH adjustment to meet the same goals.

The above examples indicate the importance of continual monitoring and addition of a pH adjustment chemical for the prevention of corrosion. Implementation of the various options studied and discussed in this memorandum involves the blending of either raw or treated surface water with groundwater pumped from the Buckman Well Field. Careful consideration of the individual and blended water quality is necessary for proper design of treatment facilities to minimize system corrosion and increase chemical stability of the water. Therefore, computer modeling was used to facilitate the proper conceptual design of the MRC WTP.

Rothberg, Tamburini, and Winsor Model

The Rothberg, Tamburini and Winsor (RTW) Model for Water Process and Corrosion Chemistry is a spreadsheet-based computer model that was developed to assist in evaluating water chemistry associated with precipitation/coagulation and the corrosion and scaling potential of water.

The model requires the user to input initial water quality characteristics such as TDS, pH, alkalinity, and temperature, and the concentration of calcium, chloride, and sulfate. For blending scenarios, the user enters characteristics of both waters and the blending ratio. The user can also enter the amount of chemicals added during treatment. The model uses the input data to calculate theoretical water quality characteristics of the treated water before and after precipitation. Table 2 presents a description of several of the theoretical water quality characteristics calculated with the RTW model.

Table 2. Summary of the Calculated RTW Model Theoretical Water Quality Characteristics

Characteristic	Definition/Corrosion Influence	Desired Range
Alkalinity	Refers to the concentration of carbonates and bicarbonates present in water. In general, corrosivity decreases with increasing alkalinity. Additional information given in Table 1.	> 40 mg/L
pH	Defines the amount of free acidity in water. Usually, higher pH means higher alkalinity, thus lower buffering capacity. Corrosivity increases with decreasing pH. Additional information given in Table 1.	6.8 to 9.3
Precipitation Potential	Refers to the potential for precipitation of $CaCO_3$. The desired potential should range between slight undersaturation and slight super-saturation. Higher precipitation potential equates to an increase in scaling.	4 to 10 mg/L
Langelier Saturation Index (LSI)	LSI is a measure of the scaling potential of a water source. Scaling is caused by the accumulation of calcium, TDS, and bicarbonate. LSI is the difference between the actual pH of the water and the pH at which scaling occurs. A slightly positive LSI indicates that scaling may occur, producing a protective layer between the pipe and the water that may limit corrosion. A LSI just slightly positive (e.g., 0.5) provides the benefit of scaling (such as development of a protective coating) without the adverse effects of excessive scaling. Conversely, with a negative LSI, CaCO3 is dissolved and the water tends to become corrosive. A slightly negative LSI (-0.5) may have no adverse impact.	> 0
Ryznar Index (RI)	RI is similar to the LSI in that it determines the scaling potential of the water. The RI is equal to two times the pH at which scaling occurs, minus the actual pH. An RI of 6 or less is most desirable and an RI of 8 or more indicates corrosion may be pervasive. In between 6 and 8 slight corrosion may occur but it may not cause problems in the system.	<6
Aggressiveness Index (AI)	The AI gives an indication of how quickly (or aggressively) corrosion will take place. Low values indicate a low pH, hardness, and buffering capacity. Waters with an AI less than 10 will attack exposed metal in pipes and tanks. AI values between 10 and 12 are considered slightly or moderately aggressive while water with an AI greater than 12 will not be aggressive to exposed surfaces.	>12

Sources:

The Revised Guidance Manual for Selecting Lead and Copper Control Strategies, EPA.

The Rothberg, Tamburini & Winsor Model for Water Process and Corrosion Chemistry User's Guide (V.4.0), American Water Works Association.

The descriptions given in Table 2 are interim water quality characteristics reported by the RTW model. If the modeling results indicate that $CaCO_3$ precipitation will not occur, only interim water quality characteristics are reported. In this case, the calcium carbonate precipitation potential (CCPP) is reported greater than 0. If the water is super-saturated (CCPP greater than 0), precipitation occurs and final water quality characteristics are calculated and reported by the model. Super-saturated water precipitates the $CaCO_3$ to reduce the CCPP to 0, which is theoretical saturation. In the table presented in the modeling results, some of the results show the water is super-saturated with a CCPP greater than 0. In these cases, the reported values are final water quality characteristics. In most cases, interim water quality characteristics are reported because the modeling showed the water to have a CCPP less than 0.

Modeling and/or Blending Scenarios

The main consideration for the modeling was the corrosion potential, as based mainly upon the LSI and RI values as discussed in Table 2. For this study, the RTW model was utilized to analyze five distinct scenarios for the Buckman Direct Diversion Project. The model and/or blending scenarios are briefly described below:

- Scenario 1: Baseline evaluation of Buckman Wells 1 through 9 to determine if the current conditions promote corrosion or scaling. The characteristics for the well water calculated in this scenario served as the modeled characteristic "goals" for the treated water from the MRC WTP.
- Scenario 2: The raw water collected from the proposed location of the Buckman Intake Structure on the Rio Grande was modeled. Assuming the raw water continuously flows through ductile iron (DI) pipe, the potential for corrosion or scaling was analyzed as a single source.
- Scenario 3: The treated water from the Municipal Recreation Complex (MRC) Water Treatment Plant (WTP) was blended with water from Buckman Wells 10 through 13.
- Scenario 4: The treated water from the MRC WTP was blended with the water from Buckman Wells 1 through 9.
- Scenario 5: The treated water from the MRC WTP was blended with the water from the Buckman Wells 1 through 13.

Modeling Results

Modeling runs were completed for the five scenarios listed above. Upon collection of the initial water quality characteristics, RTW was utilized to predict the water quality characteristics. Additionally, RTW sensitivity analyses were performed to limit the number of possible scenarios and/or runs. The sections below present the results of the RTW modeling and/or blending for each scenario.

Scenario 1: Buckman Wells 1 through 9

The Buckman Well Field has been in operation for nearly 30 years. Although one well was replaced (Well 3) and some wells are newer, the system has operated consistently without any scaling or corrosion problems. Individual RTW runs were performed based upon input data from Buckman Wells 1 through 9 to determine their water quality characteristics. Input data for the model was collected from historical water quality data obtained from City records or from laboratory analytical data collected on October 28, 2004 as part of this study. This information (presented in Table 3 below) was used to evaluate if the desired ranges of water quality characteristics, as reported by the RTW model and presented in Table 2, are achieved in the Buckman system.

Table 3. Summary of RTW Model Output for Scenario 1, Individual Buckman Wells (Wells 1 through 9)

RTW Calculated Interim Water Quality Characteristic	Water Quality Characteristics (No Additional Treatment)									
	Desired Range	Well 1	Well 2	Well 3[1]	Well 4	Well 5[1]	Well 6	Well 7	Well 8	Well 9[1]
Alkalinity	> 40 mg/L	179 mg/L	268 mg/L	329 mg/L	431 mg/L	657 mg/L	225 mg/L	269 mg/L	205 mg/L	282 mg/L
pH	6.8 to 9.3	8.29	7.46	7.54	7.24	6.93	7.46	7.68	7.82	8.09
Precipitation Potential[2]	4 to 10 mg/L	-2.77 mg/L	-11.45 mg/L	1.39 mg/L	-0.38 mg/L	44.70 mg/L	-11.12 mg/L	-2.37 mg/L	-6.92 mg/L	1.75 mg/L
Langelier Saturation Index[2]	> 0	-0.26	-0.32	0.03	0.00	0.29	-0.34	-0.08	-0.46	0.11
Ryznar Index[2]	<6	8.82	8.10	7.49	7.25	6.47	8.14	7.84	8.74	7.92
Aggressiveness Index[2]	>12	11.44	11.45	11.78	11.76	12.07	11.38	11.65	11.25	11.85

[1]Water is super-saturated (precipitation potential greater than 0), final water quality characteristics presented.
[2]Interim water quality characteristic (precipitation potential less than 0) presented unless noted otherwise.

The water quality characteristics of the Buckman wells shown in Table 3 indicate that most wells produce slightly corrosive water (LSI slightly negative). However, Wells 3, 5 and 9 have a precipitation potential with Well 5 having the highest potential. The alkalinity and the pH vary greatly by well but are within the RTW model's desired range. The Ryznar index is higher than the desire range for many of the wells and the aggressiveness index is higher than the desired range for all but one well. However, a review of the parameter descriptions in Table 2 indicates the values fall within the slight to moderately corrosive or aggressive range. No corrosion or scaling problems are apparent in the Buckman Well system based upon the long operating history. Based upon the values shown in Table 3, the slightly corrosive and aggressive characteristics of the water have proven to be acceptable within the City of Santa Fe's distribution system.

One cause of water customer complaints related to the corrosiveness of the water is caused by alternating water quality in the distribution system. The discussion of Tucson Water's experience above mentions that the pH of the surface water was not consistently maintained. The treated surface water was fed into the distribution system with different characteristics and when a lower pH water was introduced, it would remove the protective scaling from the walls of the pipe and expose iron bacteria that would cause significant discoloration of the water. The bacteria and scale would then redeposit on the walls at a higher pH only to be removed again at a lower pH. The result was ongoing problems with color in the water causing staining of customer's fixtures, clothing, and severe aesthetic issues. Tucson's experience is an example of why matching the water quality characteristics of two different water sources can greatly minimize the potential for corrosion, scaling, discoloration and other aesthetic issues in the distribution system.

Although the Buckman well water is not optimally conditioned per the RTW model results, the operating history indicates that it works for Santa Fe. The treated Rio Grande water will be introduced into the City's distribution system in two locations. One location is at Buckman Booster Station 3 where it will be blended with the Buckman Well Field water and pumped to the 10-million-gallon tank, chlorinated, fluoridated and distributed. Otherwise, the water will be pumped south and distributed in the west and south portions of the City's system. This water could theoretically be blended with Buckman well water, City well water, or surface water from the Canyon Road WTP. The scope of this study is to evaluate blending of the treated Rio Grande water with Buckman well water. The water characteristics shown in Table 3 were utilized as a treatment goal during modeling of the Rio Grande water. An effort to match the finished water quality of the Rio Grande water during operation of the MRC WTP will minimize changing conditions in the distribution system producing relatively stable water with less potential for customer complaints and regulatory compliance problems.

Scenario 2: Raw Rio Grande Water

For Scenario 2, RTW runs were completed using input data from samples collected from the Rio Grande. The samples were taken from the proposed location of the Buckman Direct Diversion Structure and analyzed for a variety of water quality parameters by the pertinent EPA Test Methods. Samples were collected during three periods of the year: spring run-off (May 21, 2003), summer monsoon (August 8, 2003), and fall low flow (October 28, 2003). The results of the three rounds of sampling were compared against historical water quality for the Rio Grande obtained from the USGS Otowi Gaging Station located just upstream of the diversion location. The analytical results from the discrete samples were all within the normal range of data at Otowi. For sensitivity analysis purposes, RTW modeling runs were conducted for all three discrete testing periods. The sensitivity analyses showed that the spring and fall data resulted in the most varied water characteristics and therefore represented the best case and worst case scenarios. An average run was also conducted. The results of the three runs (Spring, Fall, and Average) are presented in Table 4.

Table 4. Summary of RTW Model Output for Scenario 2, Raw Rio Grande Water

RTW Calculated Interim Water Quality Characteristic	Desired Range[1]	Raw Rio Grande Water Quality Characteristics		
		Spring	Fall[2]	Average[2]
Alkalinity	179-657 mg/L	100 mg/L	108 mg/L	110 mg/L
pH	6.8 to 8.3	7.20	8.03	7.72
Precipitation Potential[3]	-11.45 to 44.70 mg/L	-10.14 mg/L	22.10 mg/L	5.40 mg/L
Langelier Saturation Index[3]	-0.46 to 0.29	-0.45	1.28	0.42
Ryznar Index[3]	6.5 to 8.8	8.11	6.33	7.21
Aggressiveness Index[3]	11.3 to 12.1	10.72	12.64	11.68

[1]Desired range shown is based upon the Buckman Wells range reported in Table 3.
[2]Water is super-saturated (precipitation potential greater than 0); final water quality characteristics presented.
[3]Interim water quality characteristic (precipitation potential less than 0) presented unless noted otherwise

The water quality characteristics presented in Table 4 show that the raw water quality varies significantly from the spring run-off to the fall low flow. In the spring, the water is slightly corrosive and moderately aggressive based upon the slightly negative LSI and higher Ryznar Index. Alternately, in the fall, the water has a high scaling potential. Therefore, adjustment of the MRC WTP water's pH and alkalinity is required.

Scenario 3: Blending - Treated Rio Grande Water with Buckman Wells 10 through 13
Treated Rio Grande water will be blended with Buckman well water in the distribution system. The four newer Buckman wells (10 through 13) are located closer to the distribution system and will be less expensive to operate due to lower pumping costs. Therefore, it is likely these wells may be operated solely at certain times of the year. Scenario 3 blends treated Rio Grande water with Buckman wells 10 through 13. For Scenario 3, additional RTW runs were completed using the modeled raw Rio Grande water quality characteristics from Scenario 2 as input. The chemical doses were applied until finished water quality characteristics similar to the Buckman well water quality were achieved. A sensitivity analysis was conducted to determine if there was a significant difference in the achievable finished water quality during different seasons. Based upon the RTW sensitivity analyses, only the "average" water quality characteristics (the average between the Spring and Fall characteristics) were used for scenarios 3 through 5. Therefore, desired chemical treatment dosages were determined based upon the average water quality characteristics of the Rio Grande.

Five water treatment chemicals will be added to the raw Rio Grande water at the MRC WTP. The selected chemicals utilized for RTW modeling are as follows:

- Sulfuric acid – used to lower pH for optimal coagulation
- Aluminum sulfate (alum) – used as a coagulant to bind suspended solids
- Sodium hypochlorite – used for primary and secondary disinfection
- Hydrofluosilicic acid – used for fluoridation
- Soda ash – used to raise pH of finished water

The selected dose range for each chemical was based upon the results of jar testing, the expected enhanced coagulation pH, the desired final water pH, and experience. Additional RTW sensitivity analyses were performed to determine the effects of larger or smaller chemical dosages. Based upon the results of these sensitivity analyses, the "average" chemical dosages (the average between the high and low dosages) were used for Scenarios 3 through 5. The average drinking water treatment chemical dosages are as follows:

- Sulfuric acid – 10 mg/L (dosage required to lower pH to 6.8)
- Aluminum sulfate (alum) - 25 mg/L
- Sodium hypochlorite – 1.5 mg/L
- Hydrofluosilicic acid – 1.0 mg/L
- Soda ash – 40 mg/L (added to finished water; dosage required to raise pH until water is saturated, but not super- or under-saturated). Alternately, sodium hydroxide (caustic soda) was modeled for pH adjustment to achieve the same results as soda ash.

Using the chemical dosages listed above, approximately 50 percent of the treated Rio Grande water was blended with water from the Buckman Wells 10 through 13. The blending ratio was based upon the difference between the capacity of the Buckman Well Field system (8.9 mgd) and of Wells 10 through 13. Water samples were taken from each of the four wells after development of the well. The samples were laboratory analyzed for a variety of water quality parameters by the pertinent EPA Test Methods. Weighted averages were calculated, based upon the individual well flow rates, for the RTW input values of the well water quality characteristics.

Chemical application, consisting of sodium fluoride and MIOX will ultimately be administered to the Buckman Well water at the 10-million-gallon tank. Sodium fluoride and MIOX are not chemicals included in the RTW model. Therefore, hydrofluosilicic acid and sodium hypochlorite were utilized at a dose of 0.5 mg/L and 1.5 mg/L, respectively. For Scenario 3, RTW runs were performed to determine the effects of applying these chemicals before and after blending with the Rio Grande water. Chemical application after blending represents blending MRC WTP water with Buckman Well water at Booster 3 and pumping to the 10-million-gallon tank. Chemical application before blending represents blending MRC WTP water with Buckman Well water in other portions of the system south of the MRC WTP.

After initial separate modeling runs of the Rio Grande water treatment and the Buckman Wells 10 through 13, blended modeling runs were conducted. The three discrete blending runs were performed using the treated Rio Grande water and the well analytical data for the RTW input values. Results of the runs are presented in Table 5 below.

Table 5. Summary of RTW Model Output for Scenario 3, Blending Treated Rio Grande Water with Buckman Wells 10 through 13

RTW Calculated Interim Water Quality Characteristic	Desired Range[1]	Blended Water Quality Characteristics		
		No Additional Treatment	Treatment Applied After Blending	Treatment Applied to Well Water Prior to Blending
Alkalinity	179-657 mg/L	154 mg/L	153 mg/L	154 mg/L
pH	6.8 to 8.3	7.76	7.75	7.76
Precipitation Potential	-11.45 to 44.70 mg/L	-5.53 mg/L	-5.58 mg/L	-5.50 mg/L
Langelier Saturation Index	-0.46 to 0.29	-0.32	-0.33	-0.31
Ryznar Index	6.5 to 8.8	8.39	8.40	8.39
Aggressiveness Index	11.3 to 12.1	11.43	11.42	11.44

[1]Desired range shown is based upon the Buckman Wells range reported in Table 3.

As shown in Table 5, all modeling results indicate that the blended water characteristics are nearly identical to the Buckman well characteristics shown in Table 3. The water is slightly corrosive and has a slightly lower pH and precipitation potential. These characteristics can be adjusted by adding more soda ash to the finished water at the MRC WTP.

Scenario 4: Blending - Treated Rio Grande Water with Buckman Wells 1 through 9

Treated Rio Grande water will be blended with Buckman well water in the distribution system. There are nine Buckman wells located within the Buckman well field near the Rio Grande. Permitting requirements and source management may dictate the sole use of the Wells 1 through 9 at certain times of the year. Scenario 3 blends treated Rio Grande water with Buckman Wells 1 through 9. For Scenario 4, RTW runs were completed using the average treated Rio Grande water quality characteristics and chemical dosages from Scenario 3 as input. Using the chemical dosages listed in Scenario 3, 25 and 75 percent of the treated Rio Grande water was blended with water from the Buckman Wells 1 through 9. The two blending percentages were selected solely to test a wide blending ratio range. The representative water quality characteristics for Buckman Wells 1 through 9 were obtained from historical water quality data obtained from the City for each well, in addition to samples collected on October 28, 2003 as part of this project. Ranges and averages were calculated from the available data and used for the RTW input values of the well water quality characteristics. Sensitivity analyses were conducted separately and it was determined that the average values were sufficient for use as input values.

Chemical application, consisting of sodium fluoride and MIOX will ultimately be administered to the Well water at the 10-million-gallon tank. Sodium fluoride and MIOX are not chemicals included in the RTW model. Therefore, hydrofluosilicic acid and sodium hypochlorite were utilized at a dose of 0.5 mg/L and 1.5 mg/L, respectively. For Scenario 4, RTW runs were performed to determine the effects of applying these chemicals before and after blending with the Rio Grande water. Chemical application after blending represents blending MRC WTP water with Buckman water at Booster 3 and pumping to the 10-million-gallon tank. Chemical application before blending represents blending MRC WTP water with Buckman water in other portions of the system south of the MRC WTP.

The three discrete blending runs were performed using the treated Rio Grande water and the well data for the RTW input values. Results of the runs are presented in Table 6 below.

Table 6. Summary of RTW Model Output for Scenario 4, Blending Treated Rio Grande Water with Buckman Wells 1 through 9

RTW Calculated Interim Water Quality Characteristic	Desired Range[2]	Blended Water Quality Characteristics[1]		
		No Additional Treatment	Treatment Applied After Blending	Treatment Applied to Well Water Prior to Blending
Alkalinity	179-657 mg/L	(25%) 273 mg/L, (75%) 177 mg/L	(25%) 273 mg/L, (75%) 177 mg/L	(25%) 273 mg/L, (75%) 177 mg/L
pH	6.8 to 8.3	(25%) 7.63, (75%) 7.61	(25%) 7.63, (75%) 7.60	(25%) 7.63, (75%) 7.61
Precipitation Potential	-11.45 to 44.70 mg/L	(25%) –2.46 mg/L, (75%) –7.59 mg/L	(25%) –2.50 mg/L, (75%) –7.64 mg/L	(25%) –2.54 mg/L, (75%) –7.60 mg/L
Langelier Saturation Index	-0.46 to 0.29	(25%) -0.06, (75%) -0.30	(25%) -0.06, (75%) -0.31	(25%) -0.06, (75%) -0.30
Ryznar Index	6.5 to 8.8	(25%) 7.75, (75%) 8.22	(25%) 7.75, (75%) 8.23	(25%) 7.75, (75%) 8.22
Aggressiveness Index	11.3 to 12.1	(25%) 11.72, (75%) 11.46	(25%) 11.72, (75%) 11.45	(25%) 11.72, (75%) 11.46

[1]Two values presented for Blended Water Quality Characteristics.
[2]Desired range shown is based upon the Buckman Wells range reported in Table 3.
(25%) = 25% of blended water is treated Rio Grande water.
(75%) = 75% of blended water is treated Rio Grande water.

The blending ratios do not appear to greatly impact the characteristics of the blended water. The three indices (LSI, RI and AI) change slightly but are within the range of characteristics shown for wells 1 through 9 in Table 3. This is a significant finding because the flow rate from the Buckman well field can vary greatly depending upon the number of wells in operation. Monitoring of the system operation will allow operators to adjust chemical doses at the plant to achieve a finished water pH to match the well water pH as conditions change.

Scenario 5: Blending - Treated Rio Grande Water with All Buckman Wells

Treated Rio Grande water will be blended with Buckman well water in the distribution system. There are a total of 13 Buckman wells. It is likely that some of the wells located near the river (Wells 1 through 9) will be operated in combination with the wells located closer to the 10-million-gallon tank (Wells 10 through 13). Therefore, modeling of a mix of the wells was conducted. For Scenario 5, RTW runs were completed using the average treated Rio Grande water quality characteristics and chemical dosages from Scenario 3 as input and well water quality characteristics from Scenarios 3 and 4 as input.

Using the chemical dosages listed in Scenario 3, approximately 85 percent of the treated Rio Grande water was blended with water from all of the Buckman Wells (Wells 1 through 13). Since all of the Wells will not be online at the same time, hypothetical circumstances were modeled as follows:

- Treated Rio Grande water with Wells 12 and 13 and Wells 1, 6, 7, and 8. These "low concentration" wells were selected based upon their low alkalinity and TDS concentrations.
- Treated Rio Grande water with Wells 10 and 11 and Wells 2, 3, 4, and 5. These "high concentration" wells were selected based upon their high alkalinity and TDS concentrations.

Averages were calculated for the RTW input values for both the "low concentration" and "high concentration" blending circumstances for the Well water quality characteristics.

Chemical application, consisting of sodium fluoride and MIOX will ultimately be administered to the Well water at the 10-million-gallon tank. Sodium fluoride and MIOX are not chemicals included in the RTW model. Therefore, hydrofluosilicic acid and sodium hypochlorite were utilized at a dose of 0.5 mg/L and 1.5 mg/L, respectively. For Scenario 5, RTW runs were performed to determine the effects of applying these chemicals before and after blending with the Rio Grande water. Chemical application after blending represents blending MRC WTP water with Buckman water at Booster 3 and pumping to the 10-million-gallon tank. Chemical application before blending represents blending MRC WTP water with Buckman water in other portions of the system south of the MRC WTP.

The three discrete blending runs were performed using the average treated Rio Grande water and the "low concentration" well data for the RTW input values. Results of the runs are presented in Table 7 below.

Table 7. Summary of RTW Model Output for Scenario 5, Blending Treated Rio Grande Water with Buckman "Low Concentration" Wells

RTW Calculated Interim Water Quality Characteristic	Desired Range[2]	Blended Water Quality Characteristics[1]		
		No Additional Treatment	Treatment Applied After Blending	Treatment Applied to Well Water Prior to Blending
Alkalinity	179-657 mg/L	135 mg/L	135 mg/L	135 mg/L
pH	6.8 to 8.3	7.63	7.63	7.63
Precipitation Potential	-11.45 to 44.70 mg/L	-8.01 mg/L	-8.01 mg/L	-8.01 mg/L
Langelier Saturation Index	-0.46 to 0.29	-0.45	-0.45	-0.45
Ryznar Index	6.5 to 8.8	8.52	8.52	8.52
Aggressiveness Index	11.3 to 12.1	11.31	11.31	11.31

[1]Wells 1, 6, 7, 8, 12 and 13.
[2]Desired range shown is based upon the Buckman Wells range reported in Table 3.

The three discrete blending runs were performed using the average treated Rio Grande water and the "high concentration" well data for the RTW input values. Results of the runs are presented in Table 8 below.

Table 8. Summary of RTW Model Output for Scenario 5, Blending Treated Rio Grande Water with Buckman "High Concentration" Wells

RTW Calculated Interim Water Quality Characteristic	Desired Range[2]	Blended Water Quality Characteristics[1]		
		No Additional Treatment	Treatment Applied After Blending	Treatment Applied to Well Water Prior to Blending
Alkalinity	179-657 mg/L	151 mg/L	151 mg/L	151 mg/L
pH	6.8 to 8.3	7.58	7.58	7.58
Precipitation Potential	-11.45 to 44.70 mg/L	-8.73 mg/L	-8.79 mg/L	-8.73 mg/L
Langelier Saturation Index	-0.46 to 0.29	-0.41	-0.41	-0.41
Ryznar Index	6.5 to 8.8	8.41	8.41	8.41
Aggressiveness Index	11.3 to 12.1	11.35	11.35	11.35

[1]Wells 2, 3, 4, 5, 10 and 11
[2]Desired range shown is based upon the Buckman Wells range reported in Table 3.

Tables 7 and 8 indicate similar blended water quality characteristics can be produced in all scenarios with only slight variations in the indices. The blended water characteristics are similar to the well characteristics ("goal" characteristics) shown in Table 3.

Discussion of Results

Based upon the extensive RTW modeling, variances in the theoretical water quality characteristics were minimal once the MRC WTP water was treated to match the Buckman well water characteristics and blended at varying ratios.

Evaluating the various treatments and blending scenarios for the Santa Fe source waters, it appears that the treated and/or blended waters will have nearly the same characteristics as the well waters if the pH of the finished treated water is adjusted with soda ash or sodium hydroxide (caustic soda). Therefore, corrosion and scaling in the piping and distribution systems will be no more or no less problematic when blended with the Buckman well water. One pipeline that will see varying water conditions and possibly alternating corrosive and scale actions is the raw water pipeline between the Rio Grande and the MRC WTP. However, this will not be a problem with a properly designed pipeline and will only result in changing doses of water treatment chemicals at the MRC WTP. Consideration of the pipeline and pipeline lining materials within the proposed raw water pipeline and in the existing distribution system is important since corrosive water can attack the pipeline materials. Soft water with low mineral content, as in the raw Rio Grande water during some portions of the year, can leach the lime from the concrete resulting in the pH of the water being elevated and the pipeline compromised. Formation of a scale (as will occur during other periods of the year in the raw water line) or blending with harder water (such as Buckman water) will minimize these adverse affects.

The City's distribution system is constructed with a variety of materials including PVC, cast iron, ductile iron, galvanized iron, concrete cylinder, asbestos cement, steel, and copper. The Santa Fe Water Division GIS information obtained in April 2002 was utilized to determine the amount of each type of pipe present in the system. From the GIS data, nearly 42 percent of the system is constructed with cast iron, nearly 12 percent with ductile iron, just under 2 percent is galvanized iron and very small percentages (one half a percent each) is steel and copper. These numbers do not include the materials present on the customer side of the water service where copper is common. Since corrosion can adversely affect metal pipe, Santa Fe will have to monitor water quality characteristics and chemical dosage requirements periodically to minimize the potential for regulatory compliance problems. However, all of the modeling indicates that pH adjustment with soda ash or sodium hydroxide is sufficient to match the Buckman well water quality.

The water treatment chemicals and doses were confirmed by the modeling to be appropriate for adequate conditioning of the finished water to match the Buckman well water quality. Figure 1 depicts the confirmed chemical additions, as modeled, at the MRC WTP. These chemical additions are discussed further in related technical memoranda. Figure 2 depicts the blending of the treated water directly with the Buckman well water at Booster Station 3 and the 10-million-gallon tank.

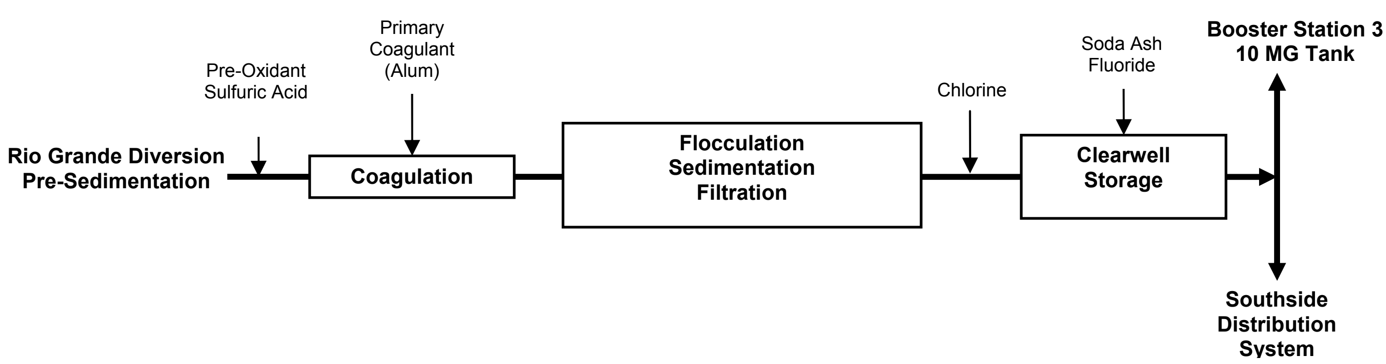

Figure 1. MRC WTP Treatment Train as Modeled

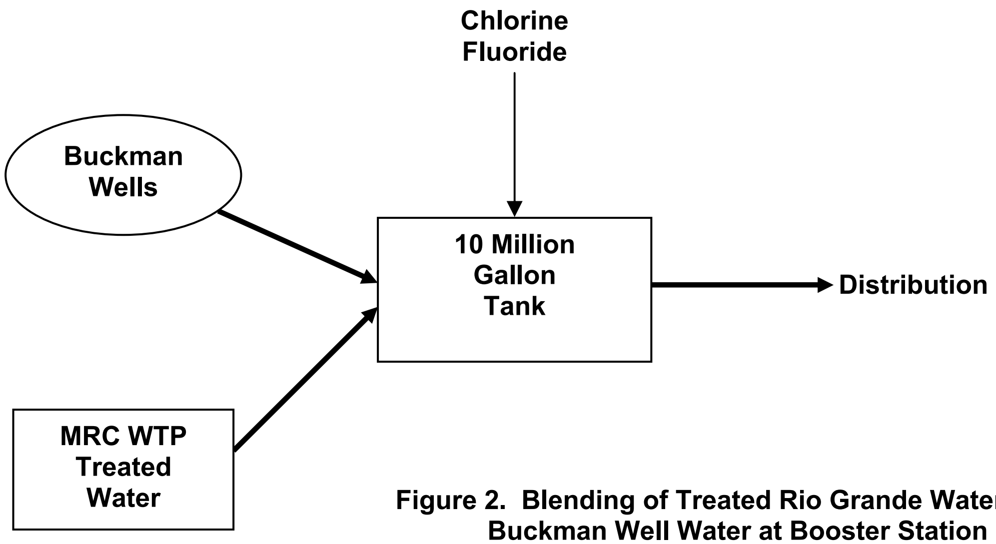

Figure 2. Blending of Treated Rio Grande Water with Buckman Well Water at Booster Station 3 and 10-Million-Gallon Tank as Modeled

Because of the limited nature of this study, a detailed evaluation of the proper corrosion control methodology is recommended prior to operation of the water treatment and conveyance facilities. The detailed evaluation may consist of a pipe loop study or corrosion coupon testing of all water sources, including treated Rio Grande water, Buckman well water, City well water, and treated Canyon Road WTP water are blended. During operation of the expanded water system, operators will have to monitor the raw water quality to predict chemical feed concentration changes. It is also recommended that water quality characteristics, as well as chemical feed dosages, for the other water sources be evaluated/monitored periodically.

APPENDIX J
LABORATORY RESULTS

PINNACLE LABORATORIES

2709-D Pan American Freeway NE
Albuquerque, New Mexico 87107
Phone (505) 344-3777
Fax (505) 344-4413

RECEIVED
JUN 20 2004
CAMP DRESSER & McKEE INC.
ALBUQUERQUE

PL I.D. **305098**

June 17, 2003

CDM, Inc.
121 Tijeras Ave. NE
Suite 1000
Albuquerque, NM 87102

Project Name/Number: (NONE) 1257-TEST

Attention: Theresa Brooks

On **05/21/03**, Pinnacle Laboratories Inc., (ADHS License No. AZ0643), received a request to analyze **aqueous** samples. The samples were analyzed with EPA methodology or equivalent methods. The results of these analyses and the quality control data, which follow each set of analyses, are enclosed.

Radiological Chemistry analyses were performed by General Engineering Laboratories, LLC. Charleston, SC.

All remaining analyses were performed by Environmental Health Laboratories, Inc. South Bend, IN.

If you have any questions or comments, please do not hesitate to contact us at (505) 344-3777.

H. Mitchell Rubenstein, Ph.D.
General Manager

MR:jt

Enclosure

PINNACLE LABORATORIES

2709-D Pan American Freeway NE
Albuquerque, New Mexico 87107
Phone (505) 344-3777
Fax (505) 344-4413

CLIENT	: CAMP DRESSER & McKEE, INC.	DATE RECEIVED	: 05/21/03
PROJECT #	: 1257-TEST		
PROJECT NAME	: (NONE)	REPORT DATE	: 06/17/03

PL ID: 305098

	PINNACLE ID #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTED
01	305098-01	RG-1	AQUEOUS	05/21/03

---TOTALS---

MATRIX	#SAMPLES
AQUEOUS	1

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE
Albuquerque, New Mexico 87107

Contact: Mitch Rubenstein
Project: PO# 305098

Report Date: June 10, 2003

Client Sample ID: RG-1 / 305098-01
Sample ID: 80775001
Matrix: Water
Collect Date: 21-MAY-03 12:45
Receive Date: 22-MAY-03
Collector: Client

Project: PINL01203
Client ID: PINL001

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Metals Analysis-ICP-MS											
3005/6020 Uranium Federal											
Uranium		2.57	0.020	0.200	ug/L	1	BAJ	05/31/03	1740	254266	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	CWS1	05/30/03	1300	254265

llowing Analytical Methods were performed

Method	Description	Analyst Comments
1	SW846 3005/6020	

Notes:
The Qualifiers in this report are defined as follows :

< Result is less than amount reported.
> Result is greater than amount reported.
B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
P The response between the confirmation column and the primary column is >40%D.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
Y QC Samples were not spiked with this compound.
h Sample preparation or preservation holding time exceeded.

The above sample is reported on an "as received" basis.

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE
Albuquerque, New Mexico 87107

Contact: Mitch Rubenstein
Project: PO# 305098

Report Date: June 10, 2003

Client Sample ID: RG-1 / 305098-01
Sample ID: 80775001

Project: PINL01203
Client ID: PINL001

Parameter	Qualifier	Result	DL	RL	Units	DF	AnalystDate	Time	Batch	Method

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Stacy Griffin.

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE
Albuquerque, New Mexico 87107

Contact: Mitch Rubenstein
Project: PO# 305098

Report Date: June 11, 2003

Client Sample ID:	RG-1 / 305098-01	Project:	PINL01203
Sample ID:	80775001	Client ID:	PINL001
Matrix:	Water		
Collect Date:	21-MAY-03 12:45		
Receive Date:	22-MAY-03		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	DF	AnalystDate	Time	Batch	Method
Rad Gas Flow Proportional Counting										
GFPC, Ra228, Liquid										
Radium-228	U	0.926		3.00	pCi/L		AF1 06/04/03	1210	253591	1
GROSSAB										
ALPHA		5.22		5.00	pCi/L		BJB1 06/06/03	1317	255748	2
BETA		7.14		5.00	pCi/L					
Rad Radium-226										
s Cell, Ra226, liquid										
m-226	U	0.184		1.00	pCi/L		CAF1 06/05/03	1230	254281	3

The following Analytical Methods were performed

Method	Description	Analyst Comments
1	EPA 904.0 Modified	
2	EPA 900.0	
3	EPA 903.1 Modified	

Notes:
The Qualifiers in this report are defined as follows :

< Result is less than amount reported.
> Result is greater than amount reported.
B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
P The response between the confirmation column and the primary column is >40%D.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
Y QC Samples were not spiked with this compound.
h Sample preparation or preservation holding time exceeded.

The above sample is reported on an "as received" basis.

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE
Albuquerque, New Mexico 87107

Contact: Mitch Rubenstein
Project: PO# 305098

Report Date: June 11, 2003

Client Sample ID: RG-1 / 305098-01
Sample ID: 80775001

Project: PINL01203
Client ID: PINL001

Parameter	Qualifier	Result	DL	RL	Units	DF	AnalystDate	Time	Batch	Method

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Stacy Griffin.

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Client :	Pinnacle Labs, Inc 2709D Pan American Freeway NE Albuquerque, New Mexico	Report Date: June 10, 2003 Page 1 of 1
Contact:	Mitch Rubenstein	
Workorder:	80775	

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Metals Analysis - ICPMS Federal										
Batch 254266										
QC1200431922 80775001 DUP										
Uranium		2.57		2.58	ug/L	0		(0%-20%)	BAJ	05/31/03 17:46
QC1200431928 LCS										
Uranium	50.0			52.3	ug/L		105	(80%-120%)		05/31/03 17:34
QC1200431921 MB										
Uranium			U	ND	ug/L					05/31/03 17:27
QC1200431926 80775001 MS										
Uranium	50.0	2.57		55.2	ug/L		105	(75%-125%)		05/31/03 17:52
QC1200431924 80775001 SDILT										
Uranium		2.57		0.505	ug/L	1.71				05/31/03 17:58

Notes:

The Qualifiers in this report are defined as follows:

- < Result is less than amount reported.
- > Result is greater than amount reported.
- Target analyte was detected in the sample as well as the associated blank.
- BD Flag for results below the MDC or a flag for low tracer recovery.
- E Concentration of the target analyte exceeds the instrument calibration range.
- H Analytical holding time exceeded.
- J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
- P The response between the confirmation column and the primary column is >40%D.
- U Indicates the target analyte was analyzed for but not detected above the detection limit.
- UI Uncertain identification for gamma spectroscopy.
- X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
- Y QC Samples were not spiked with this compound.
- h Sample preparation or preservation holding time exceeded.

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more.

^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptence criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.

For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: June 11, 2003

Client : Pinnacle Labs, Inc
2709D Pan American Freeway NE
Albuquerque, New Mexico

Contact: Mitch Rubenstein

Workorder: 80775

Parmname	NOM		Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date	Time
Rad Gas Flow												
Batch 253591												
QC1200430002 80775001 DUP												
Radium-228		U	0.926	U	0.768	pCi/L	^		(+/-3.00)	AF1	06/04/03	12:10
QC1200430003 LCS												
Radium-228	18.1				15.0	pCi/L		83	(75%-125%)		06/04/03	12:40
QC1200430001 MB												
Radium-228					1.02	pCi/L					06/04/03	12:10
Batch 255748												
QC1200435805 80775001 DUP												
Alpha			5.22		5.09	pCi/L			(0%-20%)	BJB1	06/06/03	13:17
Beta			7.14		8.34	pCi/L			(0%-20%)			
QC1200435808 LCS												
Alpha	10.5				8.94	pCi/L		85	(75%-125%)		06/06/03	10:19
Beta	33.9				34.1	pCi/L		100	(75%-125%)			
QC1200435804 MB												
Alpha				U	-0.028	pCi/L					06/06/03	13:17
r				U	0.0542	pCi/L						
.1200435806 80775001 MS												
Alpha	105		5.22		134	pCi/L		123	(75%-125%)		06/06/03	16:21
Beta	339		7.14		399	pCi/L		115	(75%-125%)			
QC1200435807 80775001 MSD												
Alpha	105		5.22		123	pCi/L		113	(75%-125%)			
Beta	339		7.14		398	pCi/L		115	(75%-125%)			
Rad Ra-226												
Batch 254281												
QC1200431977 80775001 DUP												
Radium-226		U	0.184	U	0.379	pCi/L	^		(+/-1.00)	CAF1	06/05/03	12:30
QC1200431979 LCS												
Radium-226	11.1				12.2	pCi/L		110	(75%-125%)		06/05/03	13:10
QC1200431976 MB												
Radium-226				U	0.0584	pCi/L					06/05/03	12:30
QC1200431978 80775001 MS												
Radium-226	22.3	U	0.184		23.1	pCi/L		103	(75%-125%)			

Notes:
The Qualifiers in this report are defined as follows:

- < Result is less than amount reported.
- > Result is greater than amount reported.
- B Target analyte was detected in the sample as well as the associated blank.
- BD Flag for results below the MDC or a flag for low tracer recovery.
- E Concentration of the target analyte exceeds the instrument calibration range.
- H Analytical holding time exceeded.
- J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.

GENERAL ENGINEERING LABORATORIES, LLC

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QC Summary

Workorder: 80775

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date	Time

- P The response between the confirmation column and the primary column is >40%D.
- U Indicates the target analyte was analyzed for but not detected above the detection limit.
- UI Uncertain identification for gamma spectroscopy.
- X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
- Y QC Samples were not spiked with this compound.
- h Sample preparation or preservation holding time exceeded.

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptence criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

Pinnacle Laboratories, Inc. — Interlab Chain of Custody

Date: 5/21/03 Page: 1

Network Project Manager: Jacinta Tenorio

Pinnacle Laboratories, Inc.
2709-D Pan American Freeway, NE
Albuquerque, NM 87107
(505) 344-3777 Fax (505) 344-4413

Standard data package.

807731.

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Metals (8) RCRA	TCLP RCRA (8) Metals	Metals-13 PP List	Metals-TAL (23 Metals)		TOX	TOC	Gen Chemistry:		Oil and Grease (Method 413.1)	Volatile Organics GC/MS (8260)	BOD	COD	Pesticides/PCB (608/8081/8082)	Herbicides (615/8151)	PNA (8310)/8270 SIMS	8260 (TCLP 1311) ZHE		Base/Neutral Acid Compounds GC/MS (625/8270)	Uranium (ICP-MS)	Radium 226+228	Gross Alpha/Beta	TO-14	NUMBER OF CONTAINERS
RG-1/305098-01	5/21/03	1245	AQ																					X	X	X		

PROJECT INFORMATION	
PROJECT #:	305098
PROJ. NAME:	CDM
QC LEVEL:	STD. IV
QC REQUIRED:	MS MSD BLANK
TAT:	STANDARD RUSH!!
DUE DATE:	6/12
RUSH SURCHARGE:	—
CLIENT DISCOUNT:	—
SPECIAL CERTIFICATION REQUIRED:	YES NO

COMMENTS:

SAMPLE RECEIPT	
Total Number of Containers	1
Chain of Custody Seals	No
Received Intact?	Y
Received Good Cond./Cold	Y
LAB NUMBER:	

SAMPLES SENT TO:	
PENSACOLA - STL-FL	
ESL - OR	
ATEL - AZ	
ATEL - MARION	
ATEL - MELMORE	
EHL	
GEL	X
U OF MIAMI	
WCAS	
WOHL	

RELINQUISHED BY: 1.	RELINQUISHED BY: 2.
Signature: Francine Tenorio Time: 1730	Signature: Time:
Printed Name: Francine Tenorio Date: 5/21/03	Printed Name: Date:
Pinnacle Laboratories, Inc.	Company

RECEIVED BY: 1.	RECEIVED BY: 2.
Signature: J. Harley Time: 0920	Signature: Time:
Printed Name: J. Harley Date: 5/22/03	Printed Name: Date:
Company GEL	Company

_nvironmental Health Laboratories
The Nation's Drinking Water Laboratory

110 S. Hill Street
South Bend, IN 46617
574.233.4777
800.332.4345
Fax: 574.233.8207
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NELAP NARRATIVE PAGE

Client: Pinnacle Laboratories

Report #: 890087-96NP

EHL is a NELAP accredited laboratory. All reported results meet the requirements of the NELAP standards.

EHL contact person: Jim Vernon

NELAP requires complete reporting of deviations from method requirements, regardless of the suspected impact on the data. Quality control failures not reported within the report summary are noted here.

Method 525.2

Results are potentially biased due to matrix interference as demonstrated by the low recovery of the IS-chrysene-d12 (64%) outside the acceptance limits of 70-130%, which caused the SS-triphenylphosphate to be biased high (156%) outside the acceptance limits of 70-130%.

There were no additional quality control failures.

Data Technician I 6/4/03

Reviewed By Title Date

Jessie Yarab Client Services Rep 6-5-03

Finalized By Title Date

nvironmental Health Laboratories
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South Bend, IN 46617
574.233.4777
800.332.4345
Fax: 574.233.8207
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LABORATORY REPORT

Client: Pinnacle Laboratories
Attn: Mitch Rubenstein, PhD.
2709 D Pan American Freeway NE
Albuquerque, NM 87107

Report : 890087-96(87-91)

Priority: Standard Written

Status: Final

Sampling Point: RG-1 / 305098-01

Samples Submitted: Five drinking water samples

Copies to: None

-----------------Collected-------------------
Date: 05/21/03 Time: 12:45 By: Client

-----------------Received-------------------
Date: 05/22/03 Time: 09:00

.PORT SUMMARY

True color and turbidity were detected in the samples submitted for analysis at the concentrations indicated, which are both greater than their current respective SMCLs. None of the other analytes included in the detailed parameter list were detected in the sample submitted for analysis at concentrations which exceeded, or were equivalent to, their current respective ALs, MCLs or SMCLs.

Note: Sample containers were provided by the client.

Note: See attached page for additional comments.

Detailed quantitative results are presented on the following pages.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (574) 233-4777.

Note: This report may not be reproduced, except in full, without written approval from Environmental Health Laboratories.

Reviewed By: [signature] Date: 6/4/03

.ized By: Jessie Karab Date: 6-5-03

Client: Pinnacle Laboratories

Report : 890087-96(87-91)

Sampling Point: RG-1 / 305098-01

GENERAL CHEMISTRY

PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Analysis Time	Lab Number
Fluoride	380-75WE	0.1	**0.4**	4	mg/L	05/27/03	11:28	890089
Nitrate	353.2	0.1	< 0.1	10	mg/L as N	05/28/03	14:57	890089
Nitrite	353.2	0.01	**0.01**	1	mg/L as N	05/22/03	16:16	890089

PARAMETER	SDWA Method	MRL *	Results	SMCL	Units	Analysis Date	Analysis Time	Lab Number
Alkalinity, Bicarbonate	2320B	1.0	**100**	---	mg CaCO3/L	05/23/03	08:59	890089
Alkalinity, Carbonate	2320B	1.0	< 1.0	---	mg CaCO3/L	05/23/03	08:59	890089
Alkalinity, Total	2320B	1.0	**100**	---	mg CaCO3/L	05/23/03	08:59	890089
Bromide	300.0	0.01	**0.03**	---	mg/L	05/28/03	00:20	890089
Chloride	300.0	2.0	**6.3**	250	mg/L	05/22/03	14:04	890089
Color, True	2120B	5.0	**20**	15	pt/Co units	05/22/03	15:20	890088
Hardness, Total	2340B	0.46	**130**	---	mg CaCO3/L	NA	NA	NA
Odor	140.1	1.0	< 1.0	3	TON	05/23/03	11:40	890090
Solids, Dissolved (TDS)	160.1	10	**190**	500	mg/L	05/24/03	09:35	890089
Solids, Suspended	160.2	10	**97**	500	mg/L	05/28/03	14:10	890089
Sulfate	300.0	5.0	**43**	250	mg/L	05/22/03	14:04	890089
idity	180.1	1.0	**40**	1	NTU	05/22/03	15:34	890089

Comments:

NA = Not applicable - Result presented is based upon a calculation.

* F'" has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

Client: Pinnacle Laboratories

Report : 890087-96(87-91)

Sampling Point: RG-1 / 305098-01

METALS							
PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Lab Number
Arsenic	200.8	2.0	< 2.0	10	ug/L	05/23/03	890087
Lead	200.8	1.0	< 1.0	15 ¥	ug/L	05/23/03	890087

PARAMETER	SDWA Method	MRL *	Results	SMCL	Units	Analysis Date	Lab Number
Aluminum	200.8	2.0	**20**	50 - 200	ug/L	05/23/03	890087
Calcium	200.7	0.1	**33**	---	mg/L	05/27/03	890087
Copper	200.8	1.0	**1.4**	1000	ug/L	05/23/03	890087
Iron	200.7	0.02	**0.03**	0.3	mg/L	05/27/03	890087
Magnesium	200.7	0.1	**6.3**	---	mg/L	05/27/03	890087
Manganese	200.8	2.0	**15**	50	ug/L	05/23/03	890087
Potassium	200.7	0.2	**2.5**	---	mg/L	05/27/03	890087
Sodium	200.7	0.1	**17**	---	mg/L	05/27/03	890087

Comments:

¥ An Action Limit (AL) of 15 ug/L has been established for lead. The AL is the maximum allowable concentration of lead in public drinking water supplies when measured at selected consumer taps. Under a complex set of federal guidelines, a public water supplier must initiate remedial action if the concentration of 10% of the consumer tap lead measurements exceeds 15 ug/L.

* has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

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The Nation's Drinking Water Laboratory

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Fax: 574.233.8207
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LABORATORY REPORT

Client: Pinnacle Laboratories
Attn: Mitch Rubenstein, PhD.
2709 D Pan American Freeway NE
Albuquerque, NM 87107

Report#: 890087-96(92-93+95-96)

Priority: Standard Written

Status: Final

Project/Site: RG-1 / 305098-01

Samples Submitted: Four drinking water samples

Copies to: None

Collected: 05/21/03 By: Client Received: 05/22/03

REPORT SUMMARY

Four drinking water samples were submitted for multiple parameter analyses.

Note: Sample containers were provided by the client.

Note: See attached page for additional comments.

Detailed quantitative results are presented on the following page.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (574) 233-4777.

Note: This report may not be reproduced, except in full, without written approval from Environmental Health Laboratories (EHL).

REVIEWED BY: ____________ DATE: 6/4/03

FINALIZED BY: Jessie Varab DATE: 6-5-03

Client: Pinnacle Laboratories

Report#: 890087-96(92-93+95-96)

DISSOLVED ORGANIC CARBON(DOC)—Drinking Water

Lab #	Site Description	MRL	Results	
890093	RG-1 / 305098-01	0.5	3.8	mg/L
			3.8	mg/L

Analyzed: 05/23/03 Analyst: TO Method #: 5310 C

TOTAL ORGANIC CARBON(TOC)—Drinking Water

Lab #	Site Description	MRL		Results	
890092	RG-1 / 305098-01	0.5	√	5.6	mg/L
			√	5.3	mg/L

Analyzed: 05/23/03 Analyst: TO Method #: 5310 C

UV ABS AT 254 nm(UV254)—Drinking Water

Lab #	Site Description	MRL	Results	
890095	RG-1 / 305098-01	0.009	0.124	cm^{-1}
			0.125	cm^{-1}

Analyzed: 05/22/03 / 15:40 Analyst: KS Method #: 5910 B

VOLATILE ORGANIC CHEMICALS—Drinking Water

Sampling Point: RG-1 / 305098-01 Lab #: 890096

Parameter	MRL	Results		
Geosmin	5.0	<	5.0	ng/L
2-Isobutyl-3-methoxy pyrazine(IBMP)	5.0	<	5.0	ng/L
Isopropyl methoxy pyrazine(IPMP)	5.0	<	5.0	ng/L
2-Methylisoborneol(MIB)	5.0	<	5.0	ng/L
2,4,6-Trichloroanisole(2,4,6-TCA)	5.0	<	5.0	ng/L

Analyzed: 05/23/03 Analyst: DC Method: EHL Taste & Odor

These compounds are responsible for earthy or musty odors in water supplies. Extremely low concentrations (5-10 ng/L) can be detected by the human nose. The compounds are produced by Actinomycetes, a bacteria which is commonly found in water and sediments of rivers and lakes and live within or on algae and other aquatic plants. As a result, large algal blooms in lakes and reservoirs are often responsible for odor "outbreaks" in water supplies. Granular activated carbon (GAC) is typically used to remove the compounds from water.

REFERENCES AND DEFINITIONS OF TERMS

Disinfectants/Disinfection By-Products (D/DBP) Analyses in Drinking Water

References:
1. EPA-600/4-79-020
Methods for Chemical Analysis of Water and Wastes, 1983
2. Standard Methods For the Examination of Water and Wastewater
Vol. 19, 1995
3. Methods for the Determination of Organic Compounds in Drinking Water: EPA /600/4/4-88/039

Odor in Drinking Water Analysis

Analytical Technique: Purge & Trap Capillary Gas Chromatography - Mass Spectrometry (P&T-GC/MS)

References:
1. Standard Methods for the Examination of Water and Wastewater, 19th Edition, 1995. Method 6040 C
2. "Identification and Treatment of Tastes and Odors in Drinking Water", American Water Works Association Research Foundation, Lyonnaise des Eaux-Dumez, 1987.

MRL = EHL's Minimum Reporting Limit

< = "less than." This number is the lowest reportable value by the procedure used for analysis.

√ = If dilutions were required for quantitation of specific parameters, they are indicated by a (√) preceding the result.

1 mg/L = 1 milligram per liter = 1 part per million (ppm)

cm^{-1} = UV absorption units through a one centimeter path

1 ng/L = 1 nanogram per liter = 1 part per trillion(ppt)

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Fax: 574.233.8207
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LABORATORY REPORT

Client: Pinnacle Laboratories
Attn: Mitch Rubenstein, Ph.D.
2709 D Pan American Freeway NE
Albuquerque, NM 87107

Report: 890087-96(94)

Priority: Standard Written

Status: Final

Sampling Point: RG-1 / 305098-01

Samples Submitted: One drinking water sample

Copies to: None

-----------------Collected-------------------
Date: 05/21/03 Time: 12:45 By: Client

-----------------Received-------------------
Date: 05/22/03 Time: 09:00

REPORT SUMMARY

ne of the analytes included in the detailed parameter list were detected in the sample submitted for analysis.

Note: See attached page for additional comments.

Detailed quantitative results are presented on the following page.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at 574-233-4777.

Note: This report may not be reproduced, except in full, without written approval from Environmental Health Laboratories (EHL).

Reviewed By: Date: 6/4/03

Finalized By: Jessie Karalo Date: 6-5-03

Client: Pinnacle Laboratories Report: 890087-96(94)

Sampling Point: RG-1 / 305098-01

PARAMETER	SDWA Method	MRL * (ug/L)	Results (ug/L)	MCL (ug/L)	Extraction Date	Analysis Date	Lab Number
Alachlor (Lasso)	525.2	0.1	< 0.1	2	05/29/03	06/02/03	890094
Aldicarb				postponed			
Aldicarb Sulfone				postponed			
Aldicarb Sulfoxide				postponed			
Aldrin	525.2	0.1	< 0.1	---	05/29/03	06/02/03	890094
Aroclor 1016				£			
Aroclor 1221				£			
Aroclor 1232				£			
Aroclor 1242				£			
Aroclor 1248				£			
Aroclor 1254				£			
Aroclor 1260				£			
Atrazine	525.2	0.1	< 0.1	3	05/29/03	06/02/03	890094
Benzo(a)pyrene	525.2	0.02	< 0.02	0.2	05/29/03	06/02/03	890094
Butachlor	525.2	0.1	< 0.1	---	05/29/03	06/02/03	890094
Carbaryl				---			
Carbofuran				40			
Chlordane				2			
2,4-D				70			
Dalapon				200			
1,2-Dibromo-3-chloropropane				0.2			
Dicamba				---			
Dieldrin	525.2	0.1	< 0.1	---	05/29/03	06/02/03	890094
Di(2-ethylhexyl)adipate	525.2	0.6	< 0.6	400	05/29/03	06/02/03	890094
i(2-ethylhexyl)phthalate	525.2	0.6	< 0.6	6	05/29/03	06/02/03	890094
Dinoseb				7			
Diquat				20			
Endothall				100			
Endrin	525.2	0.01	< 0.01	2	05/29/03	06/02/03	890094
Ethylene dibromide (EDB)				0.05			
Glyphosate (Round-up)				700			
Heptachlor	525.2	0.04	< 0.04	0.4	05/29/03	06/02/03	890094
Heptachlor epoxide	525.2	0.02	< 0.02	0.2	05/29/03	06/02/03	890094
Hexachlorobenzene	525.2	0.1	< 0.1	1	05/29/03	06/02/03	890094
Hexachlorocyclopentadiene	525.2	0.1	< 0.1	50	05/29/03	06/02/03	890094
3-Hydroxycarbofuran				---			
Lindane (gamma-BHC)	525.2	0.02	< 0.02	0.2	05/29/03	06/02/03	890094
Methoxychlor	525.2	0.1	< 0.1	40	05/29/03	06/02/03	890094
Methomyl				---			
Metolachlor (Dual)	525.2	0.1	< 0.1	---	05/29/03	06/02/03	890094
Metribuzin (Sencor)	525.2	0.1	< 0.1	---	05/29/03	06/02/03	890094
Oxamyl (Vydate)				200			
Pentachlorophenol				1			
Picloram (Tordon)				500			
Propachlor	525.2	0.1	< 0.1	---	05/29/03	06/02/03	890094
2,4,5-TP (Silvex)				50			
Simazine	525.2	0.07	< 0.07	4	05/29/03	06/02/03	890094
2,3,7,8-TCDD (Dioxin)				0.00003			
Toxaphene				3			

* EHL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

£ Any positive Aroclor result would require analysis for total PCB as decachlorobiphenyl by method 508A (MCL = 0.5 ug/L).

Pinnacle Laboratories, Inc.

Interlab Chain of Custody

Date: 5/21/03 Page: 1 / 1

Network Project Manager: Jacinta Tenorio

Pinnacle Laboratories, Inc.
2709-D Pan American Freeway, NE
Albuquerque, NM 87107
(505) 344-3777 Fax (505) 344-4413

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Metals (8) RCRA	TCLP RCRA (8) Metals	Metals-13 PP List	Metals-TAL (23 Metals)	Diss. Al, As, Ca, Cu, Fe, Pb, Mg, Ph	Diss. Mn, K, Na	NO2+NO3 (Speciated), Color	Gen Chemistry: TSS, TDS, SO4, Cl	Turbidity, Alkalinity, Br, F	Oil and Grease (Method 413.1)	Volatile Organics GC/MS (8260)	Odor, Taste, Total Hardness	TOC, Dissolved Organic Carbon	Pesticides/PCB (608/8081/8082)	Herbicides (615/8151)	PNA (8310)/8270 SIMS	Method 525.2 (SOC)	Ultraviolet Absorption	Base/Neutral Acid Compounds GC/MS (625/8270)	Uranium (ICP-MS)	Radium 226+228	Gross Alpha/Beta	TO-14	NUMBER OF CONTAINERS
RG-1/305098-01	5/21/03	1245	AQ						X	X	X	X	X			X	X				X	X						

IOC bottle shows NO2 but it is not listed on COC SS 5-22-03

PROJECT INFORMATION	
PROJECT #:	305098
PROJ. NAME:	CDM
QC LEVEL:	STD. IV
QC REQUIRED:	MS MSD BLANK
TAT:	STANDARD RUSH!!
DUE DATE:	6/5
RUSH SURCHARGE:	—
CLIENT DISCOUNT:	—
SPECIAL CERTIFICATION REQUIRED:	YES NO

COMMENTS:

SAMPLE RECEIPT	
Total Number of Containers	
Chain of Custody Seals	
Received Intact?	
Received Good Cond./Cold	3.4°C
LAB NUMBER:	Wet Ice

SAMPLES SENT TO:	
PENSACOLA - STL-FL	
ESL - OR	
ATEL - AZ	
ATEL - MARION	
ATEL - MELMORE	
EHL	X
GEL	
U OF MIAMI	
WCAS	
WOHL	

RELINQUISHED BY: 1.
Signature: Francine Tirino Time: 1730
Printed Name: Francine Tirivio Date: 5/21/03
Pinnacle Laboratories, Inc.

RELINQUISHED BY: 2.
Signature: Time:
Printed Name: Date:
Company

RECEIVED BY: 1.
Signature: S Spurgeon Time: 0900
Printed Name: S Spurgeon Date: 5-22-03
Company EHL

RECEIVED BY: 2.
Signature: Time:
Printed Name: Date:
Company

Environmental Health Laboratories
The Nation's Drinking Water Laboratory
www.ehl.cc

110 S. Hill Street
South Bend, IN 46617
(800) 332-4345
Fax (574) 233-8207

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Please print legi[illegible] See back for example d[illegible]ment

ORDER # 84061

SHADED AREA FOR LAB USE ONLY

CHAIN OF CUSTODY RECORD

PAGE ____ OF ____

CLIENT/COMPANY ORDERING TEST	SAMPLER (Signature)	STATE (of Sample Origin)	PWS ID#	PROJECT NAME	PO#
Pinnacle		NM			
COMPLIANCE MONITORING? YES NO		POPULATION SERVED:	SOURCE WATER:		

EHL LAB#	COLLECTION DATE	COLLECTION TIME	SAMPLING SITE	TEST NAME	SAMPLE REMARKS	# OF CONTAINERS	MATRIX CODE	TURNAROUND TIME
890087	5/21	1245 AM PM	RG-1 / 305098-01	Dissolved Al, As, Ca, Cu, Fe, Pb, Mg, Mn, K, Na,	pH<2 ss	1		
~~SS~~		AM PM		NO3 (w/sulfuric)	pH<2 ss	1		
890088		AM PM		Color		1		
890089		AM PM		TSS, TDS, SO4, Cl, Turb, Alk Carb ~~TTHM~~ Alk Br, F	NO2, NO3	2		
890090		AM PM		Odor		1		
890091		AM PM		T Hard	pH<2 ss	1		
890092		AM PM		TOC		2		
890093		AM PM		DOC		2		
890094		AM PM		525.2		2		
890095		AM PM		UV254		2		
~~SS~~		AM PM		Nitrite				
890096		AM PM		TASTE + ODOR (VOC) EHL mixed.				
		AM PM		CLIENT PROVIDED	except	for 525		

FIELD COMMENTS: CARRIER ________ AIRBILL NO. ________ COOLER NO. ________ DATE SHIPPED ss 5-22-03

SAMPLE CONTAINER

RELINQUISHED BY: (Signature)	DATE	TIME	RECEIVED BY: (Signature)	DATE	TIME
		AM PM			AM PM
RELINQUISHED BY: (Signature)	DATE	TIME	RECEIVED BY: (Signature)	DATE	TIME
		AM PM			AM PM
RELINQUISHED BY: (Signature)	DATE	TIME	RECEIVED FOR LABORATORY BY:	DATE	TIME
		AM PM	S[illegible]	5-22-03	0900 AM PM

LAB RESERVES THE RIGHT TO RETURN UNUSED PORTIONS OF NON-AQUEOUS SAMPLES TO CLIENT.

LAB COMMENTS In House COC

CONDITIONS UPON RECEIPT: (Check One) wet ☒ Iced ☐ Ambient or 3.4 °C Upon Receipt

MATRIX CODES:
DW = DRINKING WATER
GW = GROUNDWATER
SW = SURFACE WATER
PW = POOL WATER
RW = REAGENT WATER
WW = WASTEWATER

TURN-AROUND TIME (TAT) - SURCHARGES

SW = STANDARD WRITTEN (15 WORKING DAYS) 0%
RV* = RUSH (5 WORKING DAYS) VERBAL 50%
RW* = RUSH (5 WORKING DAYS) WRITTEN 75%
*-Please Call, Expedited services not available for all services.

IV* = IMMEDIATE (3 WORKING DAYS) VERBAL 100%
IW* = IMMEDIATE (3 WORKING DAYS) WRITTEN 125%
SP* = WEEKEND, HOLIDAY Call

STAT* = LESS THAN 48 HOURS Call
Samples received unannounced with less than 48 hours holding time remaining may be subject to additional surcharges.

PINNACLE LABORATORIES

Pinnacle Laboratories Inc.

CHAIN OF CUSTODY

DATE: 5/21/03 PAGE: 1 OF 2

PLI Accession #: 305098

SHADED AREAS ARE FOR LAB USE ONLY

PLEASE FILL THIS FORM IN COMPLETELY.

PROJECT MANAGER: Theresa Brooks

COMPANY: CDM
ADDRESS:

PHONE:
FAX:
BILL TO: Same
COMPANY:
ADDRESS:

SAMPLE ID	DATE	TIME	MATRIX	LAB I.D.	EPA 160.2	Sw 2540C	Sw 5310C	Sw 5910B	EPA 180.1	Sw 2120B	Sw 2320B	Sw 2340B	EPA 525.2
RG-1	5/21	1245	AQ	-01	X	X	X	X	X	X	X	X	X

PROJECT INFORMATION	
PROJ. NO.:	1257-TEST
PROJ. NAME:	
P.O. NO.:	
SHIPPED VIA:	

SAMPLE RECEIPT

NO. CONTAINERS: 2/2
CUSTODY SEALS: NA
RECEIVED INTACT: Y
BLUE ICE/ICE: 10 C

PRIOR AUTHORIZATION IS REQUIRED FOR RUSH PROJECTS

(RUSH) ☐ 24HR ☐ 72HR ☐ 1 WEEK (NORMAL) ☑

CERTIFICATION REQUIRED ☐ NM ☐ SDWA ☐ OTHER

METHANOL PRESERVATION ☐

COMMENTS: FIXED FEE ☐

Direct from field

RELINQUISHED BY: 1.
Signature: [signature] Time: 5:22
Printed Name: Theresa Brooks Date: 5/21/03
Company: CDM
See reverse side (Force Majeure)

RECEIVED BY: 1.
Signature: Time:
Printed Name: Date:
Company:

RELINQUISHED BY: 2.
Signature: Time:
Printed Name: Date:
Company:

RECEIVED BY: 2.
Signature: [signature] Time: 1722
Printed Name: [signature] Date: 05/21/03
Pinnacle Laboratories Inc.

PINNACLE LABORATORIES

Pinnacle Laboratories Inc.

CHAIN OF COUSTODY

DATE: 5/21/03 PAGE: 2 OF 2

PLI Accession #: 305098

SHADED AREAS ARE FOR LAB USE ONLY

PLEASE FILL THIS FORM IN COMPLETELY.

PROJECT MANAGER: Theresa Brooks

COMPANY: CDM
ADDRESS:
PHONE:
FAX:
BILL TO: Same
COMPANY:
ADDRESS:

SAMPLE ID	DATE	TIME	MATRIX	LAB I.D.	EPA 200.7	EPA 200.8	EPA 300.0 A/B	EPA 900.0 903.1 904.0	908.1/200.8 ~~Sec 6010 C~~ EHC Taste & odor					
KG-1	5/21	1245	AQ	01	X	X	X	X	X					

PROJECT INFORMATION

PROJ. NO.: 1257-Test
PROJ. NAME:
P.O. NO.:
SHIPPED VIA:

SAMPLE RECEIPT

NO. CONTAINERS: 10
CUSTODY SEALS: N/A
RECEIVED INTACT: Y
BLUE ICE/ICE: 10.6

PRIOR AUTHORIZATION IS REQUIRED FOR RUSH PROJECTS

(RUSH) ☐ 24HR ☐ 72HR ☐ 1 WEEK (NORMAL) ☒

CERTIFICATION REQUIRED ☐ NM ☐ SDWA ☐ OTHER

METHANOL PRESERVATION ☐

COMMENTS: FIXED FEE ☐

Direct from field

RELINQUISHED BY: 1

Signature: [signature] Time: 5:22
Printed Name: Theresa Brooks Date: 5/21/03
Company: CDM
See reverse side (Force Majeure)

RECEIVED BY: 1

Signature: Time:
Printed Name: Date:
Company:

RELINQUISHED BY: 2

Signature: Time:
Printed Name: Date:
Company:

RECEIVED BY: 2

Signature: [signature] Time: 1720
Printed Name: [signature] Date: 05.21
Pinnacle Laboratories Inc.

PINNACLE LABORATORIES

RECEIVED

SEP 08 2003

CAMP DRESSER & McKEE INC.
ALBUQUERQUE

2709-D Pan American Freeway NE
Albuquerque, New Mexico 87107
Phone (505) 344-3777
Fax (505) 344-4413

PL I.D. **308035**

September 5, 2003

Camp, Dresser & McKee, Inc.
121 Tijeras Ave NE
Suite 1000
Albuquerque, NM 87102

Project Name/Number: SANTA FE 1257-37754

Attention: Teresa Brooks

On **08/08/03**, Pinnacle Laboratories Inc., (ADHS License No. AZ0643), received a request to analyze **aqueous** samples. The samples were analyzed with EPA methodology or equivalent methods. The results of these analyses and the quality control data, which follow each set of analyses, are enclosed.

Radiological Chemistry and Uranium analyses were performed by General Engineering Laboratories, Inc. Charleston, SC.

All remaining analyses were performed by Severn Trent Laboratories, Inc. Pensacola, FL.

If you have any questions or comments, please do not hesitate to contact us at (505) 344-3777.

H. Mitchell Rubenstein, Ph.D.
General Manager

MR:jt

Enclosure

PINNACLE LABORATORIES

2709-D Pan American Freeway NE
Albuquerque, New Mexico 87107
Phone (505) 344-3777
Fax (505) 344-4413

CLIENT	: CAMP, DRESSER & McKEE, INC.	DATE RECEIVED	: 08/08/03
PROJECT #	: 1257-37754		
PROJECT NAME	: SANTA FE	REPORT DATE	: 09/04/03

PL ID: 308035

	PINNACLE ID #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTED
01	308035-01	RG-2	AQUEOUS	08/08/03

---TOTALS---

MATRIX	#SAMPLES
AQUEOUS	1

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE
Albuquerque, New Mexico 87107

Report Date: August 25, 2003

Contact: Mitch Rubenstein
Project: PO# 308035

Client Sample ID: RG-2/308035-01
Sample ID: 85946001
Matrix: Water
Collect Date: 08-AUG-03 10:30
Receive Date: 12-AUG-03
Collector: Client

Project: PINL02403
Client ID: PINL001

Parameter	Qualifier	Result	DL	RL	Units	DF	Analyst	Date	Time	Batch	Method
Metals Analysis-ICP-MS											
3005/6020 Uranium Federal											
Uranium.		1.31	0.020	0.200	ug/L	1	PRB	08/14/03	1702	270316	1

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	ARG1	08/14/03	1000	270315

llowing Analytical Methods were performed

Method	Description	Analyst Comments
1	SW846 3005/6020	

Notes:
The Qualifiers in this report are defined as follows :

< Result is less than amount reported.
> Result is greater than amount reported.
B Target analyte was detected in the sample as well as the associated blank.
BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
P The response between the confirmation column and the primary column is >40%D.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
Y QC Samples were not spiked with this compound.
h Sample preparation or preservation holding time exceeded.

The above sample is reported on an "as received" basis.

GENERAL ENGINEERING LABORATORIES, LLC

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Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE
Albuquerque, New Mexico 87107

Contact: Mitch Rubenstein
Project: PO# 308035

Report Date: August 25, 2003

Client Sample ID: RG-2/308035-01
Sample ID: 85946001

Project: PINL02403
Client ID: PINL001

Parameter	Qualifier	Result	DL	RL	Units	DF	AnalystDate	Time	Batch	Method

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Stacy Griffin.

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 · (843) 556-8171 · www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107
Contact: Mitch Rubenstein
Project: PO# 308035

Report Date: August 25, 2003

Client Sample ID: RG-2/308035-01
Sample ID: 85946001
Matrix: Water
Collect Date: 08-AUG-03
Receive Date: 12-AUG-03
Collector: Client

Project: PINL02403
Client ID: PINL001

Parameter	Qualifier	Result		DL	TPU	RL	Units	DF	AnalystDate	Time	Batch	Mtd.
Rad Gas Flow Proportional Counting												
GFPC, Ra228, Liquid												
Radium-228	U	0.770	+/-	1.62	+/-0.389	3.00	pCi/L		NKC1 08/20/03	1036	270356	1
GROSSAB												
Alpha		3.18	+/-	2.81	+/-0.896	5.00	pCi/L		MPR1 08/19/03	1756	271435	2
Beta		3.91	+/-	2.15	+/-0.676	5.00	pCi/L					
Rad Radium-226												
...s Cell, Ra226, liquid												
m-226		0.866	+/-	0.400	+/-0.195	1.00	pCi/L		JS1 08/19/03	1125	270903	4

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	ARG1	08/14/03	1000	270315

The following Analytical Methods were performed

Method	Description
1	EPA 904.0 Modified
2	EPA 900.0
3	EPA 900.0
4	EPA 903.1 Modified

Notes:
The Qualifiers in this report are defined as follows :

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U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston SC 29407 · (843) 556-8171 · www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107
Contact: Mitch Rubenstein
Project: PO# 308035

Report Date: August 25, 2003

Client Sample ID: RG-2/308035-01 Project: PINL02403
Sample ID: 85946001 Client ID: PINL001

Parameter	Qualifier	Result	DL	TPU	RL	Units	DF	AnalystDate	Time	Batch Mtd.

X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
Y QC Samples were not spiked with this compound.
h Sample preparation or preservation holding time exceeded.
The above sample is reported on an "as received" basis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Stacy Griffin.

Stacy Griffin
..wed by

GENERAL ENGINEERING LABORATORIES, LLC
2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Client :	Pinnacle Labs, Inc 2709D Pan American Freeway NE Albuquerque, New Mexico	Report Date: August 25, 2003
Contact:	Mitch Rubenstein	
Workorder:	85946	

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Metals Analysis - ICPMS Federal										
Batch 270316										
QC1200472935 85946001 DUP										
Uranium		1.31		1.28	ug/L	2		(0%-20%)	PRB	08/14/03 17:08
QC1200472931 LCS										
Uranium	50.0			50.9	ug/L		102	(80%-120%)		08/14/03 16:49
QC1200472930 MB										
Uranium			U	ND	ug/L					08/14/03 16:43
QC1200472932 85946001 MS										
Uranium	50.0	1.31		52.6	ug/L		103	(75%-125%)		08/14/03 17:15
QC1200472933 85946001 MSD										
Uranium	50.0	1.31		51.6	ug/L	2	101	(0%-20%)		08/14/03 17:21
QC1200472934 85946001 SDILT										
Uranium		1.31		0.254	ug/L	2.68				08/14/03 17:27

Notes:
The Qualifiers in this report are defined as follows:

	Result is less than amount reported.
.	Result is greater than amount reported.
B	Target analyte was detected in the sample as well as the associated blank.
BD	Flag for results below the MDC or a flag for low tracer recovery.
E	Concentration of the target analyte exceeds the instrument calibration range.
H	Analytical holding time exceeded.
J	Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
P	The response between the confirmation column and the primary column is >40%D.
U	Indicates the target analyte was analyzed for but not detected above the detection limit.
UI	Uncertain identification for gamma spectroscopy.
X	Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
Y	QC Samples were not spiked with this compound.
h	Sample preparation or preservation holding time exceeded.

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptence criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Client : Pinnacle Labs, Inc
2709D Pan American Freeway NE

Albuquerque, New Mexico

Contact: Mitch Rubenstein

Workorder: 85946

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Rad Gas Flow Proportional Counting										
Batch 270356										
QC1200473033 85946001 DUP										
Radium-228		U 0.770	U	0.519	pCi/L			(0% - 100%)	NKC1	08/20/03 10:36
	TPU:	+/-0.389		+/-0.337						
QC1200473034 LCS										
Radium-228	17.6			19.2	pCi/L		109	(75%-125%)		08/20/03 10:28
	TPU:			+/-1.87						
QC1200473032 MB										
Radium-228			U	0.485	pCi/L					08/20/03 10:36
	TPU:			+/-0.250						
Batch 271435										
QC1200475761 85946001 DUP										
Alpha		3.18		3.39	pCi/L			(0% - 20%)	MPR1	08/19/03 17:57
	TPU:	+/-0.896		+/-0.840						
Beta		3.91		4.15	pCi/L			(0% - 20%)		
	TPU:	+/-0.676		+/-0.605						
:200475764 LCS										
[illegible]	10.5			8.85	pCi/L		85	(75%-125%)		08/19/03 16:27
	TPU:			+/-1.05						
Beta	33.7			33.2	pCi/L		99	(75%-125%)		
	TPU:			+/-1.09						
QC1200475760 MB										
Alpha			U	-0.067	pCi/L					08/19/03 17:56
	TPU:			+/-0.0596						
Beta			U	0.026	pCi/L					
	TPU:			+/-0.0678						
QC1200475762 85946001 MS										
Alpha	69.8	3.18		65.5	pCi/L		89	(75%-125%)		08/19/03 16:26
	TPU:	+/-0.896		+/-7.04						
Beta	225	3.91		228	pCi/L		100	(75%-125%)		
	TPU:	+/-0.676		+/-7.36						
QC1200475763 85946001 MSD										
Alpha	69.8	3.18		74.8	pCi/L		103	(75%-125%)		08/19/03 16:27
	TPU:	+/-0.896		+/-9.18						
Beta	225	3.91		248	pCi/L		109	(75%-125%)		
	TPU:	+/-0.676		+/-7.63						
Rad Radium-226										
Batch 270903										
QC1200474350 85946001 DUP										
Radium-226		0.866		0.801	pCi/L			(0% - 100%)	JS1	08/19/03 11:25
	TPU:	+/-0.195		+/-0.188						
QC1200474352 LCS										
Radium-226	22.3			19.5	pCi/L		87	(75%-125%)		
	TPU:			+/-0.970						
QC1200474349 MB										
Radium-226				0.638	pCi/L					

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Workorder: 85946

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date	Time
Rad Radium-226											
Batch 270903											
	TPU:			+/-0.156							
QC1200474351 85946001 MS											
Radium-226	22.3	0.866		21.3	pCi/L		92	(75%-125%)			
	TPU:	+/-0.195		+/-1.02							

Notes:
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- > Result is greater than amount reported.
- B Target analyte was detected in the sample as well as the associated blank.
- BD Flag for results below the MDC or a flag for low tracer recovery.
- E Concentration of the target analyte exceeds the instrument calibration range.
- H Analytical holding time exceeded.
- J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
- P The response between the confirmation column and the primary column is >40%D.
- U Indicates the target analyte was analyzed for but not detected above the detection limit.
- UI Uncertain identification for gamma spectroscopy.
- Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
- (QC Samples were not spiked with this compound.
- h Sample preparation or preservation holding time exceeded.

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more.
** Indicates analyte is a surrogate compound.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptence criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

Pinnacle Laboratories, Inc. — Interlab Chain of Custody

Date: 8/11/03 Page: 1 1

Network Project Manager: Jacinta Tenorio

Pinnacle Laboratories, Inc.
2709-D Pan American Freeway, NE
Albuquerque, NM 87107
(505) 344-3777 Fax (505) 344-4413

Standard data package required.

859461

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Metals (8) RCRA	TCLP RCRA (8) Metals	Metals-13 PP List	Metals-TAL (23 Metals)	Dissolved Fe, Mn, Pb (6010)		TOC	Gen Chemistry:			Volatile Organics GC/MS (8260)	BOD	COD	Pesticides/PCB (608/8081/8082)	Herbicides (615/8151)	PNA (8310)/8270 SIMS	8260 (TCLP 1311) ZHE		Base/Neutral Acid Compounds GC/MS (625/8270)	Uranium (ICP-MS)	Radium 226+228	Gross Alpha/Beta	TO-14	NUMBER OF CONTAINERS
RG-2 / 308035 -01	8/8/03	1030	AQ																					X	X	X		

PROJECT INFORMATION	
PROJECT #:	308035
PROJ. NAME:	CDM
QC LEVEL:	STD
QC REQUIRED:	MS MSD BLANK
TAT:	STANDARD RUSH!!
DUE DATE:	8/29
RUSH SURCHARGE:	—
CLIENT DISCOUNT:	—
SPECIAL CERTIFICATION REQUIRED:	YES NO

COMMENTS:

SAMPLE RECEIPT	
Total Number of Containers	
Chain of Custody Seals	
Received Intact?	
Received Good Cond./Cold	
LAB NUMBER:	

SAMPLES SENT TO:	
PENSACOLA - STL-FL	
ESL - OR	
ATEL - AZ	
ATEL - MARION	
ATEL - MELMORE	
EHL	
GEL	X
U OF MIAMI	
WCAS	
WOHL	

RELINQUISHED BY: 1.	RELINQUISHED BY: 2.
Signature: Francine Tenorio Time: 1700	Signature: Time:
Printed Name: Francine Tenorio Date: 8/11/03	Printed Name: Date:
Pinnacle Laboratories, Inc.	Company

RECEIVED BY: 1.	RECEIVED BY: 2.
Signature: [signature] Time: 900	Signature: Time:
Printed Name: Nick Osborn Date: 8/12/03	Printed Name: Date:
Company	Company

Environmental Health Laboratories
The Nation's Drinking Water Laboratory

110 S. Hill Street
South Bend, IN 46617
574.233.4777
800.332.4345
Fax: 574.233.8207
www.ehl.cc

NELAP NARRATIVE PAGE

Client: Pinnacle Laboratories

Report #: 925861-71NP

EHL is a NELAP accredited laboratory. All reported results meet the requirements of the NELAP standards.

EHL contact person: Jim Van Fleit

NELAP requires complete reporting of deviations from method requirements, regardless of the suspected impact on the data. Quality control failures not reported within the report summary are noted here.

Method 140.1

The sample submitted for analysis was analyzed beyond the two day holding time. The client was notified of the situation, and analysis was authorized by Francine Torivio of Pinnacle Laboratories.

There were no quality control failures.

William Reeve — Reporting Manager — 8/25/03
Reviewed By — Title — Date

Finalized By — Title — 8-25-03
Date

A Division of Underwriters Laboratories Inc.

ıvironmental Health Laboratories
The Nation's Drinking Water Laboratory

110 S. Hill Street
South Bend, IN 46617
574.233.4777
800.332.4345
Fax: 574.233.8207
www.ehl.cc

LABORATORY REPORT

Client: Pinnacle Laboratories
Attn: Mitch Rubenstein, Ph.D.
2709 D Pan American Freeway NE
Albuquerque, NM 87107

Report#: 925861-71(61-64+67)

Priority: Standard Written

Status: Final

Project/Site: 308035 / RG-2/308035-01

Samples Submitted: Five drinking water samples

Copies to: None

Collected: 08/08/03 By: Client Received: 08/09/03

REPORT SUMMARY

Five drinking water samples were submitted for multiple parameter analyses.

Note: Sample containers were provided by the client.

Note: See attached page for additional comments.

Detailed quantitative results are presented on the following page.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (574) 233-4777.

Note: This report may not be reproduced, except in full, without written approval from Environmental Health Laboratories (EHL).

REVIEWED BY: William Reeve Reporting Manager DATE: 8/25/03

FINALIZED BY: [signature] DATE: 8-25-03

NITROGEN, AMMONIA—Drinking Water

Lab #	Site Description	MRL		Results	
925867	RG-2/308035-01	0.1	<	0.1	mg/L

Analyzed: 08/18/03 Analyst: EE Method #: 4500-NH_3 D

DISSOLVED ORGANIC CARBON(DOC)—Drinking Water

Lab #	Site Description	MRL	Results	
925864	RG-2/308035-01	0.5	**3.6**	**mg/L**
			3.7	**mg/L**

Analyzed: 08/11/03 Analyst: NB Method #: 5310 C

TOTAL ORGANIC CARBON(TOC)—Drinking Water

Lab #	Site Description	MRL	Results	
925863	RG-2/308035-01	0.5	**3.2**	**mg/L**
			3.2	**mg/L**

Analyzed: 08/11/03 Analyst: NB Method #: 5310 C

UV ABS AT 254 nm(UV254)—Drinking Water

Lab #	Site Description	MRL	Results	
925861	RG-2/308035-01 (Filtered)	0.009	**0.103**	cm^{-1}
			0.103	cm^{-1}
925862	RG-2/308035-01 (Unfiltered)	0.009	**0.149**	cm^{-1}
			0.149	cm^{-1}

Analyzed: 08/09/03 / 11:48 Analyst: KS Method #: 5910 B

REFERENCES AND DEFINITIONS OF TERMS

Disinfectants/Disinfection By-Products (D/DBP) Analyses in Drinking Water

References:
1. EPA-600/4-79-020
Methods for Chemical Analysis of Water and Wastes, 1983
2. Standard Methods For the Examination of Water and Wastewater
Vol. 19, 1995
3. Methods for the Determination of Organic Compounds in Drinking
Water: EPA /600/4/4-88/039

MCL = (Maximum Contaminant Levels) are the maximum allowable concentrations of regulated parameters in public drinking water supplies. Monitoring requirements for public supplies are not currently applicable to private (residential) water systems.

MRL = EHL's Minimum Reporting Limit

< = "less than." This number is the lowest reportable value by the procedure used for analysis.

1 mg/L = 1 milligram per liter = 1 part per million (ppm)

cm^{-1} = UV absorption units through a one centimeter path

Environmental Health Laboratories
The Nation's Drinking Water Laboratory

110 S. Hill Street
South Bend, IN 46617
574.233.4777
800.332.4345
Fax: 574.233.8207
www.ehl.cc

LABORATORY REPORT

Client: Pinnacle Laboratories
Attn: Mitch Rubenstein, Ph.D.
2709 D Pan American Freeway NE
Albuquerque, NM 87107

Report : 925861-71(65-66+68-71)

Priority: Standard Written

Status: Final

Sampling Point: 308035 / RG-2/308035-01

Samples Submitted: Six drinking water samples

Copies to: None

Collected			Received	
Date: 08/08/03	Time: 10:30	By: Client	Date: 08/09/03	Time: 09:15

REPORT SUMMARY

Aluminum, color (true), iron, manganese and turbidity were detected in the sample submitted for analysis at the concentrations indicated, which all exceeded their current respective SMCLs. None of the other analytes included in the detailed parameter list were detected in the sample submitted for analysis at concentrations which exceeded, or were equivalent to, their current respective ALs, MCLs or SMCLs.

Note: Sample containers were provided by the client.

Note: Nitrogen, kjeldahl analysis performed by Sherry Laboratories, Columbus, IN.

Note: See attached page for additional comments.

Detailed quantitative results are presented on the following pages.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (574) 233-4777.

Note: This report may not be reproduced, except in full, without written approval from Environmental Health Laboratories.

Reviewed By: William Rivera Reporting Manager Date: 8/25/03

Finalized By: Date: 8-25-03

A Division of Underwriters Laboratories Inc.

Client: Pinnacle Laboratories

Report : 925861-71(65-66+68-71)

Sampling Point: 308035 / RG-2/308035-01

GENERAL CHEMISTRY

PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Analysis Time	Lab Number
Nitrate	300.0	0.5	**9.4**	10	mg/L as N	08/09/03	11:37	925866
Nitrite	353.2	0.01	< 0.01	1	mg/L as N	08/09/03	11:08	925866
Nitrogen, Kjeldahl	351.2	1.0	**1.2**	---	mg/L	08/14/03	NA	925871

PARAMETER	SDWA Method	MRL *	Results	SMCL	Units	Analysis Date	Analysis Time	Lab Number
Alkalinity, Bicarbonate	2320B	1.0	**69**	---	mg CaCO3/L	08/12/03	15:21	925868
Alkalinity, Carbonate	2320B	1.0	< 1.0	---	mg CaCO3/L	08/12/03	15:21	925868
Alkalinity, Total	2320B	1.0	**69**	---	mg CaCO3/L	08/12/03	15:21	925868
Chloride	300.0	2.0	**3.5**	250	mg/L	08/12/03	13:19	925868
Color (True)	2120B	5.0	**20**	15	pt/Co units	08/10/03	10:18	925869
Hardness, Total	2340B	0.46	**120**	---	mg CaCO3/L	NA	NA	NA
Odor	140.1	1.0	< 1.0	3	TON	08/11/03	14:30	925870
Solids, Dissolved (TDS)	160.1	10	**220**	500	mg/L	08/12/03	17:40	925866
Solids, Suspended (TSS)	160.2	10	**38**	---	mg/L	08/14/03	14:45	925866
Sulfate	300.0	5.0	**47**	250	mg/L	08/12/03	13:19	925868
dity	180.1	1.0	**59**	1	NTU	08/10/03	09:58	925866

Comments:

NA = Not applicable - Result presented is based upon a calculation.

* E[illegible] has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

A Division of Underwriters Laboratories Inc.

Client: Pinnacle Laboratories

Report : 925861-71(65-66+68-71)

Sampling Point: 308035 / RG-2/308035-01

METALS

PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Lab Number
Arsenic	200.8	2.0	< 2.5 †	10	ug/L	08/13/03	925865
Lead	200.8	1.0	**1.8**	15 ¥	ug/L	08/13/03	925865

PARAMETER	SDWA Method	MRL *	Results	SMCL	Units	Analysis Date	Lab Number
Aluminum	200.8	2.0	**2500**	50 - 200	ug/L	08/13/03	925865
Calcium	200.7	0.1	**38**	---	mg/L	08/14/03	925865
Copper	200.8	1.0	**3.9**	1000	ug/L	08/13/03	925865
Iron	200.7	0.02	**2.2**	0.3	mg/L	08/14/03	925865
Magnesium	200.7	0.1	**7.4**	---	mg/L	08/14/03	925865
Manganese	200.8	2.0	**57**	50	ug/L	08/13/03	925865
Potassium	200.7	0.2	**3.1**	---	mg/L	08/14/03	925865
Sodium	200.7	0.1	**13**	---	mg/L	08/14/03	925865

Comments:

¥ An Action Limit (AL) of 15 ug/L has been established for lead. The AL is the maximum allowable concentration of lead in public drinking water supplies when measured at selected consumer taps. Under a complex set of federal guidelines, a public water supplier must initiate remedial action if the concentration of 10% of the consumer tap lead measurements exceeds 15 ug/L.

† Result presented is based upon a dilution factor of 1.25.

* FHL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

Pinnacle Laboratories, Inc. — Interlab Chain of Custody — OK71

Date: 8/8/03 Page: 1

Network Project Manager: Jacinta Tenorio

Pinnacle Laboratories, Inc.
2709-D Pan American Freeway, NE
Albuquerque, NM 87107
(505) 344-3777 Fax (505) 344-4413

UV Absorbs Filtered has been filtered.

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	UV Absorbs (Filtered)	UV Absorbs (Unfiltered)	Total Organic Carbon	Dissolved Organic Carbon	Hardness	TDS, TSS, Turbidity, NO2, NO3	~~TKN,~~ NH3, ~~NO2 + NO3~~ SS	Alkalinity + Bicarb/Carb, Cl, SO4	Color	Odor (Threshold)	Al, As, Ca, Cu, Fe, Pb	Mg, Mn, K, Na	TKN	NUMBER OF CONTAINERS
RG-2/308035-01	08/08/2003	1030	AQ	925861	X	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	SS	
				925862		X												
				925863			X		pH<2 SS									2
				925864				X										2
				925865					X						X	X	pH<2 SS	
				925866						X								
				925867							X	pH<2 SS						
				925868								X						
				925869									X					
				925870										X				

CLIENT PROVIDED SAMPLE CONTAINER

925871

SS ~~X~~ ~~X~~ X TO Sherry Labs pH<2 SS

PROJECT INFORMATION	SAMPLE RECEIPT		SAMPLES SENT TO:	
PROJECT #: 308035	Total Number of Containers		PENSACOLA - STL-FL	
PROJ. NAME: CDM	Chain of Custody Seals		ESL - OR	
QC LEVEL: STD.	Received Intact?		ATEL - AZ	
QC REQUIRED: MS MSD BLANK	Received Good Cond./Cold		ATEL - MARION	
TAT: STANDARD	LAB NUMBER:		ATEL - MELMORE	
			EHL	X
DUE DATE: 08/22/03	COMMENTS:		GEL	
RUSH SURCHARGE: NO			U OF MIAMI	
CLIENT DISCOUNT: NO			WCAS	
SPECIAL CERTIFICATION REQUIRED: NO			WOHL	

RELINQUISHED BY: ~~X~~ SS 1.	RELINQUISHED BY: 2.
Signature: Francine Tenorio Time: 1700	Signature: Time:
Printed Name: Francine Tenorio Date: 8/8/03	Printed Name: Date:
Pinnacle Laboratories, Inc.	Company
RECEIVED BY: 1.	**RECEIVED BY: 2.**
Signature: Time:	Signature: [signature] Time: 0915 AM
Printed Name: Date:	Printed Name: [illegible] Date: 08/09/03
Company	Company EHC

PINNACLE LABORATORIES

Pinnacle Laboratories Inc.

CHAIN OF CUSTODY

DATE: 8/8/03 PAGE: 1 OF 2

PLI Accession #: 308035

SHADED AREAS ARE FOR LAB USE ONLY

PROJECT MANAGER: Teresa Brooks

COMPANY: CDM INC
ADDRESS:
PHONE:
FAX:
BILL TO: Same
COMPANY:
ADDRESS:

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB I.D.	U.V. Absorbs Filtered	U.V. Absorbs Unfiltered	TOC	DOC	Hardness + Metals	TDS, TSS, Turb, TKN, NO3, Alk, Cl, SO4, NO2, NH3	Color	Odor (Threshold)	Gross α/B	
RG-2	8/8/03	1030	AQ	01	X	X	X	X	X	X	X	X	X	17

PROJECT INFORMATION	
PROJ. NO.:	1257-37754
PROJ. NAME:	Santa Fe
P.O. NO.:	
SHIPPED VIA:	

PRIOR AUTHORIZATION IS REQUIRED FOR RUSH PROJECTS

(RUSH) ☐ 24HR ☐ 72HR ☐ 1 WEEK (NORMAL) ☑

CERTIFICATION REQUIRED ☐ NM ☐ SDWA ☐ OTHER

METHANOL PRESERVATION ☐

COMMENTS: FIXED FEE ☐

Metals - Al, As, Ca, Cu, Fe
Pb, Mg, Mn, K, Na

Direct from Field

SAMPLE RECEIPT	
NO. CONTAINERS	17
CUSTODY SEALS	Y/N/NA
RECEIVED INTACT	Yes
BLUE ICE/ICE	ice

RELINQUISHED BY: 1.
Signature: [signature] Time: 1551
Printed Name: Date: 8/8/03
Company: CDM
See reverse side (Force Majeure)

RELINQUISHED BY: 2.
Signature: Time:
Printed Name: Date
Company:

RECEIVED BY: 1.
Signature: Time:
Printed Name: Date
Company:

RECEIVED BY: 2.
Signature: [signature] Time: 1556
Printed Name: [signature] Date: 8/8/03
Pinnacle Laboratories Inc.

PLEASE FILL THIS FORM IN COMPLETELY.

PINNACLE LABORATORIES

Pinnacle Laboratories Inc.

CHAIN OF CUSTODY

DATE: 8/8/03 PAGE: 2 OF 2

PLI Accession #: 308035

SHADED AREAS ARE FOR LAB USE ONLY

PLEASE FILL THIS FORM IN COMPLETELY.

PROJECT MANAGER: Teresa Brooks

COMPANY: CDM INC
ADDRESS:

PHONE:
FAX:
BILL TO:
COMPANY: Same
ADDRESS:

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB I.D.	Ra 226/228	Total U by ICPMS								
RG-2	8/8/03	1030	AQ	01	X	X								17

PROJECT INFORMATION

PROJ. NO.: 1257-37754
PROJ. NAME: Santa Fe
P.O. NO.:
SHIPPED VIA:

SAMPLE RECEIPT

NO. CONTAINERS: 17
CUSTODY SEALS: Y/N/NA
RECEIVED INTACT: yes
BLUE ICE/ICE: ice

PRIOR AUTHORIZATION IS REQUIRED FOR RUSH PROJECTS

(RUSH) ☐ 24HR ☐ 72HR ☐ 1 WEEK (NORMAL) ☑

CERTIFICATION REQUIRED ☐ NM ☐ SDWA ☐ OTHER

METHANOL PRESERVATION ☐

COMMENTS: FIXED FEE ☐

Direct from Field

RELINQUISHED BY: 1.

Signature: Kendall Russ Time: 1551
Printed Name: Date: 8/8/03
Company: CDM
See reverse side (Force Majeure)

RELINQUISHED BY: 2.

Signature: Time:
Printed Name: Date:
Company:

RECEIVED BY: 1.

Signature: Time:
Printed Name: Date:
Company:

RECEIVED BY: (LAB) 2.

Signature: [signature] Time: 1556
Printed Name: [illegible] Date: 8/8/03
Pinnacle Laboratories Inc.

PINNACLE LABORATORIES

2709-D Pan American Freeway NE
Albuquerque, New Mexico 87107
Phone (505) 344-3777
Fax (505) 344-4413

RECEIVED

DEC 01 2003

CAMP DRESSER & McKEE INC.
ALBUQUERQUE

PL I.D. **310149**

December 1, 2003

Camp, Dresser & McKee, Inc.
121 Tijeras Ave NE, Suite 1000
Albuquerque, NM 87102

Project Name/Number: SANTA FE 1257-37754

Attention: Teresa Brooks

On **10/28/03**, Pinnacle Laboratories Inc., (ADHS License No. AZ0643), received a request to analyze **aqueous** samples. The samples were analyzed with EPA methodology or equivalent methods. The results of these analyses and the quality control data, which follow each set of analyses, are enclosed.

Radiological Chemistry analyses were performed by General Engineering Laboratories, LLC. Charleston, SC.

All remaining analyses were performed by Environmental Health Laboratories, Inc. South Bend, IN.

If you have any questions or comments, please do not hesitate to contact us at (505) 344-3777.

H. Mitchell Rubenstein, Ph.D.
General Manager

MR:jt

Enclosure

PINNACLE LABORATORIES

2709-D Pan American Freeway NE
Albuquerque, New Mexico 87107
Phone (505) 344-3777
Fax (505) 344-4413

CLIENT	: CAMP, DRESSER & McKEE, INC.	DATE RECEIVED	: 10/28/03
PROJECT #	: 1257-37754		
PROJECT NAME	: SANTA FE	REPORT DATE	: 12/01/03

PL ID: 310149

	PINNACLE ID #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTED
01	310149-01	BS	AQUEOUS	10/28/03
02	310149-02	WELL 2	AQUEOUS	10/28/03
03	310149-03	WELL 6	AQUEOUS	10/28/03
04	310149-04	WELL 7	AQUEOUS	10/28/03
05	310149-05	WELL 8	AQUEOUS	10/28/03
	310149-06	RIVER	AQUEOUS	10/28/03

---TOTALS---

MATRIX	#SAMPLES
AQUEOUS	6

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107
Contact: Mitch Rubenstein
Project: PO# 310149

Report Date: November 13, 2003

Client Sample ID:	BS/310149-01	Project:	PINL03003
Sample ID:	100808001	Client ID:	PINL001
Matrix:	Water		
Collect Date:	28-OCT-03		
Receive Date:	29-OCT-03		
Collector:	Client		

Parameter	Qualifier	Result		DL	TPU	RL	Units	DF	Analyst	Date	Time	Batch	Mtd.
Metals Analysis-ICP-MS													
3005/6020 Uranium Federal													
Uranium		6.90		0.020	+/-	0.200	ug/L	1	BAJ	11/07/03	1950	288004	1
Rad Gas Flow Proportional Counting													
GFPC, Ra228, Liquid													
Radium-228	U	0.772	+/-	1.61	+/-0.384	3.00	pCi/L		BJB1	11/07/03	0828	288704	2
'SSAB													
..pha		7.54	+/-	2.76	+/-1.25	5.00	pCi/L		BXD1	11/05/03	1027	288705	3
Beta	U	1.63	+/-	3.87	+/-0.903	5.00	pCi/L						
Rad Radium-226													
Lucas Cell, Ra226, liquid													
Radium-226	U	0.360	+/-	0.423	+/-0.147	1.00	pCi/L		JS1	11/10/03	1420	288811	4

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	CQH1	11/06/03	1500	288003

The following Analytical Methods were performed

Method	Description
1	SW846 3005/6020
2	EPA 904.0 Modified
3	EPA 900.0
4	EPA 903.1 Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Carrier/Tracer Recovery	GFPC, Ra228, Liquid	63	

Notes:
The Qualifiers in this report are defined as follows :

< Result is less than amount reported.
> Result is greater than amount reported.
Target analyte was detected in the sample as well as the associated blank.

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107

Report Date: November 13, 2003

Contact: Mitch Rubenstein
Project: PO# 310149

Client Sample ID: BS/310149-01
Sample ID: 100808001

Project: PINL03003
Client ID: PINL001

Parameter	Qualifier	Result	DL	TPU	RL	Units	DF	AnalystDate	Time	Batch Mtd.

BD Flag for results below the MDC or a flag for low tracer recovery.
E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
P The response between the confirmation column and the primary column is >40%D.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
Uncertain identification for gamma spectroscopy.
Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
Y QC Samples were not spiked with this compound.
h Sample preparation or preservation holding time exceeded.
The above sample is reported on an "as received" basis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Amy Jamison.

Amy C Jamison
Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107
Contact: Mitch Rubenstein
Project: PO# 310149

Report Date: November 13, 2003

Client Sample ID:	Well 2/310149-02	Project:	PINL03003
Sample ID:	100808002	Client ID:	PINL001
Matrix:	Water		
Collect Date:	28-OCT-03		
Receive Date:	29-OCT-03		
Collector:	Client		

Parameter	Qualifier	Result		DL	TPU	RL	Units	DF	Analyst	Date	Time	Batch	Mtd.
Metals Analysis-ICP-MS													
3005/6020 Uranium Federal													
Uranium		27.9		0.020	+/-	0.200	ug/L	1	BAJ	11/07/03	2026	288004	1
Rad Gas Flow Proportional Counting													
GFPC, Ra228, Liquid													
Radium-228	U	0.572	+/-	1.35	+/-0.319	3.00	pCi/L		BJB1	11/07/03	0828	288704	2
GROSSAB													
[illegible]a		15.3	+/-	1.86	+/-1.65	5.00	pCi/L		BXD1	11/05/03	1027	288705	3
[illegible]a	U	1.43	+/-	3.87	+/-0.899	5.00	pCi/L						
Rad Radium-226													
Lucas Cell, Ra226, liquid													
Radium-226	U	0.257	+/-	0.362	+/-0.121	1.00	pCi/L		JS1	11/10/03	1500	288811	4

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	CQH1	11/06/03	1500	288003

The following Analytical Methods were performed

Method	Description
1	SW846 3005/6020
2	EPA 904.0 Modified
3	EPA 900.0
4	EPA 903.1 Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Carrier/Tracer Recovery	GFPC, Ra228, Liquid	72	

Notes:
The Qualifiers in this report are defined as follows :

< Result is less than amount reported.
> Result is greater than amount reported.
[illegible] Target analyte was detected in the sample as well as the associated blank.
[illegible] Flag for results below the MDC or a flag for low tracer recovery.

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107
Contact: Mitch Rubenstein
Project: PO# 310149

Report Date: November 13, 2003

Client Sample ID: Well 2/310149-02 Project: PINL03003
Sample ID: 100808002 Client ID: PINL001

Parameter	Qualifier	Result	DL	TPU	RL	Units	DF	AnalystDate	Time	Batch Mtd.

E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
P The response between the confirmation column and the primary column is >40%D.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
.ab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
.QC Samples were not spiked with this compound.
h Sample preparation or preservation holding time exceeded.
The above sample is reported on an "as received" basis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Amy Jamison.

Amy Jamison
Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107
Contact: Mitch Rubenstein
Project: PO# 310149

Report Date: November 13, 2003

Client Sample ID: Well 6/310149-03
Sample ID: 100808003
Matrix: Water
Collect Date: 28-OCT-03
Receive Date: 29-OCT-03
Collector: Client

Project: PINL03003
Client ID: PINL001

Parameter	Qualifier	Result		DL	TPU	RL	Units	DF	Analyst	Date	Time	Batch	Mtd.
Metals Analysis-ICP-MS													
3005/6020 Uranium Federal													
Uranium		3.98		0.020	+/-	0.200	ug/L	1	BAJ	11/07/03	2032	288004	1
Rad Gas Flow Proportional Counting													
GFPC, Ra228, Liquid													
Radium-228		1.33	+/-	1.31	+/-0.352	3.00	pCi/L		BJB1	11/07/03	0828	288704	2
`SSAB													
na		4.89	+/-	1.85	+/-0.907	5.00	pCi/L		BXD1	11/05/03	1027	288705	3
Beta	U	2.75	+/-	3.26	+/-0.817	5.00	pCi/L						
Rad Radium-226													
Lucas Cell, Ra226, liquid													
Radium-226		0.212	+/-	0.197	+/-0.0795	1.00	pCi/L		JS1	11/10/03	1500	288811	4

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	CQH1	11/06/03	1500	288003

The following Analytical Methods were performed

Method	Description
1	SW846 3005/6020
2	EPA 904.0 Modified
3	EPA 900.0
4	EPA 903.1 Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Carrier/Tracer Recovery	GFPC, Ra228, Liquid	76	

Notes:
The Qualifiers in this report are defined as follows :

< Result is less than amount reported.
> Result is greater than amount reported.
¯arget analyte was detected in the sample as well as the associated blank.
Flag for results below the MDC or a flag for low tracer recovery.

GENERAL ENGINEERING LABORATORIES, LLC

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Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107
Contact: Mitch Rubenstein
Project: PO# 310149

Report Date: November 13, 2003

Client Sample ID: Well 6/310149-03
Sample ID: 100808003
Project: PINL03003
Client ID: PINL001

Parameter	Qualifier	Result	DL	TPU	RL	Units	DF	AnalystDate	Time	Batch Mtd.

E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
P The response between the confirmation column and the primary column is >40%D.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
ab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
QC Samples were not spiked with this compound.
h Sample preparation or preservation holding time exceeded.
The above sample is reported on an "as received" basis.

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Amy Jamison
Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107
Contact: Mitch Rubenstein
Project: PO# 310149

Report Date: November 13, 2003

Client Sample ID:	Well 7/310149-04	Project:	PINL03003
Sample ID:	100808004	Client ID:	PINL001
Matrix:	Water		
Collect Date:	28-OCT-03		
Receive Date:	29-OCT-03		
Collector:	Client		

Parameter	Qualifier	Result		DL	TPU	RL	Units	DF	Analyst	Date	Time	Batch	Mtd.
Metals Analysis-ICP-MS													
3005/6020 Uranium Federal													
Uranium		5.77		0.020	+/-	0.200	ug/L	1	BAJ	11/07/03	2038	288004	1
Rad Gas Flow Proportional Counting													
GFPC, Ra228, Liquid													
Radium-228	U	1.25	+/-	1.31	+/-0.348	3.00	pCi/L		BJB1	11/07/03	0828	288704	2
SSAB													
a		5.34	+/-	2.46	+/-1.02	5.00	pCi/L		BXD1	11/05/03	1718	288705	3
Beta		5.89	+/-	3.49	+/-0.986	5.00	pCi/L						
Rad Radium-226													
Lucas Cell, Ra226, liquid													
Radium-226		0.556	+/-	0.331	+/-0.143	1.00	pCi/L		JS1	11/10/03	1500	288811	4

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	CQH1	11/06/03	1500	288003

The following Analytical Methods were performed

Method	Description
	SW846 3005/6020
	EPA 904.0 Modified
	EPA 900.0
	EPA 903.1 Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Carrier/Tracer Recovery	GFPC, Ra228, Liquid	69	

Notes:
The Qualifiers in this report are defined as follows :

< Result is less than amount reported.
> Result is greater than amount reported.
rget analyte was detected in the sample as well as the associated blank.
lag for results below the MDC or a flag for low tracer recovery.

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107
Contact: Mitch Rubenstein
Project: PO# 310149

Report Date: November 13, 2003

Client Sample ID: Well 7/310149-04 Project: PINL03003
Sample ID: 100808004 Client ID: PINL001

Parameter	Qualifier	Result	DL	TPU	RL	Units	DF	AnalystDate	Time	Batch Mtd.

E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
P The response between the confirmation column and the primary column is >40%D.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
QC Samples were not spiked with this compound.
h Sample preparation or preservation holding time exceeded.
The above sample is reported on an "as received" basis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Amy Jamison.

Amy C Jamison

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107

Report Date: November 13, 2003

Contact: Mitch Rubenstein
Project: PO# 310149

Client Sample ID:	Well 8/310149-05	Project:	PINL03003
Sample ID:	100808005	Client ID:	PINL001
Matrix:	Water		
Collect Date:	28-OCT-03		
Receive Date:	29-OCT-03		
Collector:	Client		

Parameter	Qualifier	Result		DL	TPU	RL	Units	DF	Analyst	Date	Time	Batch	Mtd.
Metals Analysis-ICP-MS													
3005/6020 Uranium Federal													
Uranium		15.6		0.020	+/-	0.200	ug/L	1	BAJ	11/07/03	2044	288004	1
Rad Gas Flow Proportional Counting													
GFPC, Ra228, Liquid													
Radium-228	U	0.771	+/-	1.31	+/-0.318	3.00	pCi/L		BJB1	11/07/03	0828	288704	2
'SSAB													
na		9.78	+/-	2.63	+/-1.31	5.00	pCi/L		BXD1	11/05/03	1718	288705	3
Beta	U	2.36	+/-	3.39	+/-0.834	5.00	pCi/L						
Rad Radium-226													
Lucas Cell, Ra226, liquid													
Radium-226		0.327	+/-	0.200	+/-0.102	1.00	pCi/L		JS1	11/10/03	1500	288811	4

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	CQH1	11/06/03	1500	288003

The following Analytical Methods were performed

Method	Description
1	SW846 3005/6020
2	EPA 904.0 Modified
3	EPA 900.0
4	EPA 903.1 Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Carrier/Tracer Recovery	GFPC, Ra228, Liquid	83	

Notes:
The Qualifiers in this report are defined as follows :

< Result is less than amount reported.
> Result is greater than amount reported.
'arget analyte was detected in the sample as well as the associated blank.
Flag for results below the MDC or a flag for low tracer recovery.

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107
Contact: Mitch Rubenstein
Project: PO# 310149

Report Date: November 13, 2003

Client Sample ID: Well 8/310149-05
Sample ID: 100808005

Project: PINL03003
Client ID: PINL001

Parameter	Qualifier	Result	DL	TPU	RL	Units	DF	AnalystDate	Time	Batch	Mtd.

E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
P The response between the confirmation column and the primary column is >40%D.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
U[1] Uncertain identification for gamma spectroscopy.
ab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
QC Samples were not spiked with this compound.
h Sample preparation or preservation holding time exceeded.
The above sample is reported on an "as received" basis.

This data report has been prepared and reviewed in accordance with General Engineering Laboratories, LLC standard operating procedures. Please direct any questions to your Project Manager, Amy Jamison.

Amy C Jamison

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107

Contact: Mitch Rubenstein

Project: PO# 310149

Report Date: November 13, 2003

Client Sample ID:	River/310149-06	Project:	PINL03003
Sample ID:	100808006	Client ID:	PINL001
Matrix:	Water		
Collect Date:	28-OCT-03		
Receive Date:	29-OCT-03		
Collector:	Client		

Parameter	Qualifier	Result		DL	TPU	RL	Units	DF	Analyst	Date	Time	Batch	Mtd.
Metals Analysis-ICP-MS													
3005/6020 Uranium Federal													
Uranium		3.61		0.020	+/-	0.200	ug/L	1	BAJ	11/07/03	2050	288004	1
Rad Gas Flow Proportional Counting													
GFPC, Ra228, Liquid													
Radium-228	U	1.06	+/-	1.44	+/-0.365	3.00	pCi/L		BJB1	11/07/03	0828	288704	2
SSAB													
pha		4.18	+/-	2.46	+/-0.881	5.00	pCi/L		BXD1	11/05/03	1718	288705	3
Beta		5.17	+/-	3.77	+/-1.01	5.00	pCi/L						
Rad Radium-226													
Lucas Cell, Ra226, liquid													
Radium-226	U	0.054	+/-	0.381	+/-0.101	1.00	pCi/L		JS1	11/10/03	1500	288811	4

The following Prep Methods were performed

Method	Description	Analyst	Date	Time	Prep Batch
SW846 3005A	ICP-MS 3005 PREP	CQH1	11/06/03	1500	288003

The following Analytical Methods were performed

Method	Description
1	SW846 3005/6020
2	EPA 904.0 Modified
3	EPA 900.0
4	EPA 903.1 Modified

Surrogate/Tracer recovery	Test	Recovery%	Acceptable Limits
Carrier/Tracer Recovery	GFPC, Ra228, Liquid	71	

Notes:
The Qualifiers in this report are defined as follows :

< Result is less than amount reported.
> Result is greater than amount reported.
Target analyte was detected in the sample as well as the associated blank.
Flag for results below the MDC or a flag for low tracer recovery.

GENERAL ENGINEERING LABORATORIES, LLC

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Certificate of Analysis

Company : Pinnacle Labs, Inc
Address : 2709D Pan American Freeway NE

Albuquerque, New Mexico 87107
Contact: Mitch Rubenstein
Project: PO# 310149

Report Date: November 13, 2003

Client Sample ID: River/310149-06
Sample ID: 100808006

Project: PINL03003
Client ID: PINL001

Parameter	Qualifier	Result	DL	TPU	RL	Units	DF	AnalystDate	Time	Batch	Mtd.

E Concentration of the target analyte exceeds the instrument calibration range.
H Analytical holding time exceeded.
J Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
P The response between the confirmation column and the primary column is >40%D.
U Indicates the target analyte was analyzed for but not detected above the detection limit.
UI Uncertain identification for gamma spectroscopy.
ab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
QC Samples were not spiked with this compound.
h Sample preparation or preservation holding time exceeded.

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Amy Jamison

Reviewed by

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Client : Pinnacle Labs, Inc
2709D Pan American Freeway NE
Albuquerque, New Mexico
Contact: Mitch Rubenstein

Workorder: 100808

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Metals Analysis - ICPMS Federal										
Batch 288004										
QC1200517294 100808001 DUP										
Uranium		6.90		7.11	ug/L	3		(0%-20%)	BAJ	11/07/03 19:56
QC1200517293 LCS										
Uranium	50.0			54.4	ug/L		109	(80%-120%)		11/07/03 19:44
QC1200517292 MB										
Uranium			U	-0.006	ug/L					11/07/03 19:38
QC1200517295 100808001 MS										
Uranium	50.0	6.90		59.4	ug/L		105	(75%-125%)		11/07/03 20:02
QC1200517296 100808001 SDILT										
Uranium		6.90		1.43	ug/L	3.89				11/07/03 20:08
Rad Gas Flow										
Batch 288704										
QC1200519010 100808004 DUP										
˜um-228		U 1.25		1.60	pCi/L			(0%-20%)	BJB1	11/07/03 08:28
¿C1200519011 LCS										
.adium-228	17.2			17.6	pCi/L		103	(75%-125%)		
QC1200519009 MB										
Radium-228			U	0.758	pCi/L					
Batch 288705										
QC1200519013 100808003 DUP										
Alpha		4.89		4.08	pCi/L			(0%-20%)	BXD1	11/05/03 17:18
Beta		U 2.75		4.33	pCi/L			(0%-20%)		
QC1200519016 LCS										
Alpha	10.5			9.87	pCi/L		94	(75%-125%)		11/06/03 17:58
Beta	33.5			35.3	pCi/L		105	(75%-125%)		
QC1200519012 MB										
Alpha			U	0.0439	pCi/L					11/05/03 17:18
Beta			U	-0.016	pCi/L					
QC1200519014 100808003 MS										
Alpha	69.8	4.89		79.5	pCi/L		107	(75%-125%)		11/06/03 17:58
Beta	224	U 2.75		246	pCi/L		109	(75%-125%)		
Rad Ra-226										
Batch 288811										
QC1200519282 100808003 DUP										
Radium-226		0.212		0.442	pCi/L			(0%-20%)	JS1	11/10/03 15:30
QC1200519284 LCS										
Radium-226	10.7			11.5	pCi/L		108	(75%-125%)		
QC1200519281 MB										
Radium-226			U	0.0724	pCi/L					
QC1200519283 100808003 MS										
Radium-226	21.3	0.212		24.9	pCi/L		116	(75%-125%)		

ːs:
, Qualifiers in this report are defined as follows:

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Workorder: 100808

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date	Time

<	Result is less than amount reported.
>	Result is greater than amount reported.
B	Target analyte was detected in the sample as well as the associated blank.
BD	Flag for results below the MDC or a flag for low tracer recovery.
E	Concentration of the target analyte exceeds the instrument calibration range.
H	Analytical holding time exceeded.
J	Indicates an estimated value. The result was greater than the detection limit, but less than the reporting limit.
P	The response between the confirmation column and the primary column is >40%D.
U	Indicates the target analyte was analyzed for but not detected above the detection limit.
UI	Uncertain identification for gamma spectroscopy.
X	Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.
Y	QC Samples were not spiked with this compound.
h	Sample preparation or preservation holding time exceeded.

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more.

^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptence criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- RL is used to evaluate the DUP result.

For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

GENERAL ENGINEERING LABORATORIES, LLC

SAMPLE RECEIPT & REVIEW FORM

PM use only

Client: Pinnacle	SDG/ARCOC/Work Order:
Date Received: 10-29-03	PM(A) Review (ensure non-conforming items are resolved prior to signing):
Received By: MK	

	Sample Receipt Criteria	Conforming	NA	Non-Conforming	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: seals broken damaged container leaking container other (describe)
2	Samples requiring cold preservation within (4 +/- 2 C)? Record preservation method.		✓		Circle Temp device serial # 221113011 221113026 109479 109480 ice bags blue ice dry ice none other(describe) 18^C HNO_3
3	Chain of custody documents included with shipment?	✓			
4	Sample containers intact and sealed?	✓			Circle Applicable: seals broken damaged container leaking container other (describe)
5	Samples requiring chemical preservation at proper pH?	✓			Sample ID's, containers affected and observed pH:
6	VOA vials free of headspace (defined as < 6mm bubble)?		✓		Sample ID's and containers affected:
7	Samples received within holding time?	✓			Id's and tests affected:
8	Sample ID's on COC match ID's on bottles?	✓			Sample ID's and containers affected:
9	Date & time on COC match date & time on bottles?			✓	Sample ID's affected: NO DATE OR TIME ON CONTAINERS
10	Number of containers received match number indicated on COC?	✓			Sample ID's affected:
11	COC form is properly signed in relinquished/received sections?	✓			
12	Air Bill ,Tracking #'s, & Additional Comments	UPS # 12878 168 01 4358 0192			

Radiological Information	Non-RAD	RAD	RADH	RSO RAD Receipt #
What is the radiological classification of the samples?	✓			Comments:
Radioactivity Screening Results (maximum observed CPM)				*If > x2 area background is observed on a non-radioactive sample, contact the RSO to investigate.

Pi[illegible]le Laboratories, Inc.

Interlab [illegible]in of Custody

Date: 10/28/03 Page: 1 of_

Network Project Manager: Jacinta Tenorio

Pinnacle Laboratories, Inc.
2709-D Pan American Freeway, NE
Albuquerque, NM 87107
(505) 344-3777 Fax (505) 344-4413

Standard data package.

100808 /.

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Metals (8) RCRA	TCLP RCRA (8) Metals	Metals-13 PP List	Metals-TAL (23 Metals)	Dissolved Fe, Mn, Pb (6010)		TOC	Gen Chemistry:			Volatile Organics GC/MS (8260)	BOD	COD	Pesticides/PCB (608/8081/8082)	Herbicides (615/8151)	PNA (8310)/8270 SIMS	8260 (TCLP 1311) ZHE		Base/Neutral Acid Compounds GC/MS (625/8270)	Uranium (ICP-MS)	Radium 226+228	Gross Alpha/Beta	TO-14	NUMBER OF CONTAINERS
BS / 310149 -01	10/28/03	0915	AQ																					X	X	X		2
Well 2 / 310149 -02	↓	1000	↓																					X	X	X		2
Well 6 / 310149 -03	↓	0945	↓																					X	X	X		2
Well 7 / 310149 -04	↓	1010	↓																					X	X	X		2
Well 8 / 310149 -05	↓	1020	↓																					X	X	X		2
River / 310149 -06	↓	1100	↓																					X	X	X		2

PROJECT INFORMATION	
PROJECT #:	310149
PROJ. NAME:	CDM
QC LEVEL:	STD. IV
QC REQUIRED:	MS MSD BLANK
TAT:	STANDARD RUSH!!
DUE DATE:	11/11
RUSH SURCHARGE:	—
CLIENT DISCOUNT:	—
SPECIAL CERTIFICATION REQUIRED:	YES NO

COMMENTS:

SAMPLE RECEIPT	
Total Number of Containers	
Chain of Custody Seals	
Received Intact?	
Received Good Cond./Cold	
LAB NUMBER:	

SAMPLES SENT TO:	
PENSACOLA - STL-FL	
ESL - OR	
ATEL - AZ	
ATEL - MARION	
ATEL - MELMORE	
EHL	
GEL	X
U OF MIAMI	
WCAS	
WOHL	

RELINQUISHED BY: 1.
Signature: Francine Tenorio Time: 1700
Printed Name: Francine Tenorio Date: 10/28/03
Pinnacle Laboratories, Inc.

RELINQUISHED BY: 2.
Signature: Time:
Printed Name: Date:
Company

RECEIVED BY: 1.
Signature: Mike Kaslow Time: 0915
Printed Name: Mike Kaslow Date: 10-29-03
Company GEL

RECEIVED BY: 2.
Signature: Time:
Printed Name: Date:
Company

Environmental Health Laboratories
The Nation's Drinking Water Laboratory
Division of Underwriters Laboratories Inc.

110 South Hill Street
South Bend, IN 46617
Phone: (574) 233-4777
Fax: (574) 233-8207

LABORATORY REPORT

This report contains 18 pages.
(including the cover page)

If you have any questions concerning this report, please do not hesitate to call us at 1-800-332-4345 or 574-233-4777.

Environmental Health Laboratories
The Nation's Drinking Water Laboratory

110 S. Hill Street
South Bend, IN 46617
574.233.4777
800.332.4345
Fax: 574.233.8207
www.ehl.cc

NELAP NARRATIVE PAGE

Client: Pinnacle Laboratories

Report #: 960633-658+777NP

EHL is a NELAP accredited laboratory. All reported results meet the requirements of the NELAP standards.

EHL contact person: Jim Van Fleit

NELAP requires complete reporting of deviations from method requirements, regardless of the suspected impact on the data. Quality control failures not reported within the report summary are noted here.

There were no quality control failures.

Reviewed By	Title	Date
[signature]	Reporter	11/7/03

Finalized By	Title	Date
[signature]	P.M.	11-7-03

Environmental Health Laboratories
The Nation's Drinking Water Laboratory

110 S. Hill Street
South Bend, IN 46617
574.233.4777
800.332.4345
Fax: 574.233.8207
www.ehl.cc

LABORATORY REPORT

Client: Pinnacle Laboratories
Attn: Mitch Rubenstein, Ph.D.
2709 D Pan American Freeway NE
Albuquerque, NM 87107

Report : 960633-658(633-636)+777

Priority: Standard Written

Status: Final

Sampling Point: BS / 310149-01

Samples Submitted: Four drinking water samples

Copies to: None

-----------------Collected-------------------
Date: 10/28/03 Time: 09:15 By: Client

-----------------Received-------------------
Date: 10/29/03 Time: 09:15

REPORT SUMMARY

Arsenic was detected in the sample submitted for analysis at a concentration of 14 ug/L, which is greater than the current MCL of 10 ug/L. None of the other analytes included in the detailed parameter list were detected in the samples submitted for analysis at concentrations which exceeded, or were equivalent to, their current respective MCLs or SMCLs.

Note: Sample containers were provided by the client.

Note: See attached page for additional comments.

Detailed quantitative results are presented on the following page.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (574) 233-4777.
Note: This report may not be reproduced, except in full, without written approval from Environmental Health Laboratories.

Reviewed By: Steve Deming Reporter Date: 11/7/03

Finalized By: M. K. P. M. Date: 11-7-03

Client: Pinnacle Laboratories

Report : 960633-658(633-636)+777

ampling Point: BS / 310149-01

GENERAL CHEMISTRY

PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Analysis Time	Lab Number
Nitrate-Nitrite	353.2	0.1	**1.3**	10	mg/L as N	11/04/03	15:17	960634
Nitrite	353.2	0.01	< 0.01	1	mg/L as N	10/29/03	17:29	960635

PARAMETER	SDWA Method	MRL *	Results	SMCL	Units	Analysis Date	Analysis Time	Lab Number
Alkalinity, Bicarbonate	2320B	1.0	**210**	---	mg CaCO3/L	11/03/03	08:30	960636
Alkalinity, Carbonate	2320B	1.0	< 1.0	---	mg CaCO3/L	11/03/03	08:30	960636
Alkalinity, Hydroxide	2320B	1.0	< 1.0	---	mg CaCO3/L	11/03/03	08:30	960636
Alkalinity, Total	2320B	1.0	**210**	---	mg CaCO3/L	11/03/03	08:30	960636
Chloride	300.0	2.0	**4.6**	250	mg/L	10/29/03	10:18	960636
Solids, Dissolved (TDS)	2540C	10	**290**	500	mg/L	10/31/03	16:00	960636
Sulfate	300.0	5.0	**23**	250	mg/L	10/29/03	10:18	960636

METALS

PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Lab Number
enic	200.8	2.0	**14**	10	ug/L	10/29/03	960633

PARAMETER	SDWA Method	MRL *	Results	SMCL	Units	Analysis Date	Lab Number
Aluminum	200.8	2.0	**18**	50 - 200	ug/L	10/29/03	960633
Calcium	200.7	0.1	**27**	---	mg/L	10/30/03	960633
Iron	200.7	0.02	< 0.02	0.3	mg/L	10/30/03	960633
Manganese	200.8	2.0	**2.5**	50	ug/L	10/29/03	960633

Comments:

* EHL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

Environmental Health Laboratories
The Nation's Drinking Water Laboratory

110 S. Hill Street
South Bend, IN 46617
574.233.4777
800.332.4345
Fax: 574.233.8207
www.ehl.cc

LABORATORY REPORT

Client: Pinnacle Laboratories
Attn: Mitch Rubenstein, Ph.D.
2709 D Pan American Freeway NE
Albuquerque, NM 87107

Report : 960633-658(637-639)+777

Priority: Standard Written

Status: Final

Sampling Point: Well 2 / 310149-02

Samples Submitted: Three drinking water samples

Copies to: None

------------------Collected------------------
ate: 10/28/03 Time: 10:00 By: Client

------------------Received------------------
Date: 10/29/03 Time: 09:15

REPORT SUMMARY

Arsenic was detected in the sample submitted for analysis at a concentration of 12 ug/L, which is greater than the current MCL of 10 ug/L. None of the other analytes included in the detailed parameter list were detected in the samples submitted for analysis at concentrations which exceeded, or were equivalent to, their current respective MCLs or SMCLs.

Note: Sample containers were provided by the client.

Note: See attached page for additional comments.

Detailed quantitative results are presented on the following page.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (574) 233-4777.
Note: This report may not be reproduced, except in full, without written approval from Environmental Health Laboratories.

eviewed By: Steve Dungy Reporter Date: 11/7/03

Finalized By: [signature] P.M. Date: 11-7-03

Client: Pinnacle Laboratories

Report : 960633-658(637-639)+777

mpling Point: Well 2 / 310149-02

GENERAL CHEMISTRY								
PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Analysis Time	Lab Number
Nitrate-Nitrite	353.2	0.1	**1.4**	10	mg/L as N	11/04/03	15:17	960638
Nitrite	353.2	0.01	< 0.01	1	mg/L as N	10/29/03	17:30	960639

METALS							
PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Lab Number
Arsenic	200.8	2.0	**12**	10	ug/L	10/29/03	960637

PARAMETER	SDWA Method	MRL *	Results	SMCL	Units	Analysis Date	Lab Number
Aluminum	200.8	2.0	**2.7**	50 - 200	ug/L	10/31/03	960637
Calcium	200.7	0.1	**18**	---	mg/L	10/30/03	960637
Iron	200.7	0.02	**0.02**	0.3	mg/L	10/30/03	960637
Manganese	200.8	2.0	< 2.0	50	ug/L	10/29/03	960637

Comments:

*EHL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

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The Nation's Drinking Water Laboratory

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Fax: 574.233.8207
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LABORATORY REPORT

Client: Pinnacle Laboratories
Attn: Mitch Rubenstein, Ph.D.
2709 D Pan American Freeway NE
Albuquerque, NM 87107

Report : 960633-658(640-642)+777

Priority: Standard Written

Status: Final

Sampling Point: Well 6 / 310149-03

Samples Submitted: Three drinking water samples

Copies to: None

-----------------Collected-------------------
Date: 10/28/03 Time: 09:45 By: Client

-----------------Received-------------------
Date: 10/29/03 Time: 09:15

REPORT SUMMARY

None of the analytes included in the detailed parameter list were detected in the samples submitted for analysis at concentrations which exceeded, or were equivalent to, their current respective MCLs or SMCLs.

Note: Sample containers were provided by the client.

Note: See attached page for additional comments.

Detailed quantitative results are presented on the following page.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (574) 233-4777.

Note: This report may not be reproduced, except in full, without written approval from Environmental Health Laboratories.

Reviewed By: Reporter Date: 11/7/03

Finalized By: P.M. Date: 11-7-03

Client: Pinnacle Laboratories

Report : 960633-658(640-642)+777

ampling Point: Well 6 / 310149-03

GENERAL CHEMISTRY								
PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Analysis Time	Lab Number
Nitrate-Nitrite	353.2	0.1	**2.0**	10	mg/L as N	11/04/03	15:18	960641
Nitrite	353.2	0.01	< 0.01	1	mg/L as N	10/29/03	17:35	960642

METALS							
PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Lab Number
Arsenic	200.8	2.0	**4.4**	10	ug/L	10/29/03	960640

PARAMETER	SDWA Method	MRL *	Results	SMCL	Units	Analysis Date	Lab Number
Aluminum	200.8	2.0	**2.0**	50 - 200	ug/L	10/29/03	960640
Calcium	200.7	0.1	**33**	---	mg/L	10/30/03	960640
Iron	200.7	0.02	**0.05**	0.3	mg/L	10/30/03	960640
Manganese	200.8	2.0	< 2.0	50	ug/L	10/29/03	960640

Comments:

EHL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

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LABORATORY REPORT

Client: Pinnacle Laboratories
Attn: Mitch Rubenstein, Ph.D.
2709 D Pan American Freeway NE
Albuquerque, NM 87107

Report : 960633-658(643-645)+777

Priority: Standard Written

Status: Final

Sampling Point: Well 7 / 310149-04

Samples Submitted: Three drinking water samples

Copies to: None

-----------------Collected-------------------			-----------------Received-------------------	
Date: 10/28/03	Time: 10:10	By: Client	Date: 10/29/03	Time: 09:15

REPORT SUMMARY

None of the analytes included in the detailed parameter list were detected in the samples submitted for analysis at concentrations which exceeded, or were equivalent to, their current respective MCLs or SMCLs.

Note: Sample containers were provided by the client.

Note: See attached page for additional comments.

Detailed quantitative results are presented on the following page.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (574) 233-4777.

Note: This report may not be reproduced, except in full, without written approval from Environmental Health Laboratories.

Reviewed By: Stan Dugy Reporter Date: 11/7/03

Finalized By: [signature] P.M. Date: 11-7-03

Client: Pinnacle Laboratories

Report : 960633-658(643-645)+777

Sampling Point: Well 7 / 310149-04

GENERAL CHEMISTRY								
PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Analysis Time	Lab Number
Nitrate-Nitrite	353.2	0.1	**1.4**	10	mg/L as N	11/04/03	15:19	960644
Nitrite	353.2	0.01	< 0.01	1	mg/L as N	10/29/03	17:35	960645

METALS							
PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Lab Number
Arsenic	200.8	2.0	**3.7**	10	ug/L	10/29/03	960643

PARAMETER	SDWA Method	MRL *	Results	SMCL	Units	Analysis Date	Lab Number
Aluminum	200.8	2.0	**9.9**	50 - 200	ug/L	10/29/03	960643
Calcium	200.7	0.1	**33**	---	mg/L	10/30/03	960643
Iron	200.7	0.02	< 0.02	0.3	mg/L	10/30/03	960643
Manganese	200.8	2.0	< 2.0	50	ug/L	10/29/03	960643

Comments:

*EHL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

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Fax: 574.233.8207
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LABORATORY REPORT

Client: Pinnacle Laboratories
Attn: Mitch Rubenstein, Ph.D.
2709 D Pan American Freeway NE
Albuquerque, NM 87107

Report : 960633-658(646-648)+777

Priority: Standard Written

Status: Final

Sampling Point: Well 8 / 310149-05

Samples Submitted: Three drinking water samples

Copies to: None

-----------------Collected-------------------
'ate: 10/28/03 Time: 10:20 By: Client

------------------Received-------------------
Date: 10/29/03 Time: 09:15

REPORT SUMMARY

None of the analytes included in the detailed parameter list were detected in the samples submitted for analysis at concentrations which exceeded, or were equivalent to, their current respective MCLs or SMCLs.

Note: Sample containers were provided by the client.

Note: See attached page for additional comments.

Detailed quantitative results are presented on the following page.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (574) 233-4777.

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Reviewed By: Reporter Date: 11/7/03

Finalized By: P.M. Date: 11-7-03

Client: Pinnacle Laboratories

Report : 960633-658(646-648)+777

ampling Point: Well 8 / 310149-05

GENERAL CHEMISTRY								
PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Analysis Time	Lab Number
Nitrate-Nitrite	353.2	0.1	**0.7**	10	mg/L as N	11/04/03	15:20	960647
Nitrite	353.2	0.01	< 0.01	1	mg/L as N	10/29/03	17:36	960648

METALS							
PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Lab Number
Arsenic	200.8	2.0	**7.5**	10	ug/L	10/29/03	960646

PARAMETER	SDWA Method	MRL *	Results	SMCL	Units	Analysis Date	Lab Number
Aluminum	200.8	2.0	< 2.0	50 - 200	ug/L	10/29/03	960646
Calcium	200.7	0.1	**14**	---	mg/L	10/30/03	960646
Iron	200.7	0.02	< 0.02	0.3	mg/L	10/30/03	960646
Manganese	200.8	2.0	< 2.0	50	ug/L	10/29/03	960646

Comments:

EHL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

Environmental Health Laboratories
The Nation's Drinking Water Laboratory

110 S. Hill Street
South Bend, IN 46617
574.233.4777
800.332.4345
Fax: 574.233.8207
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LABORATORY REPORT

Client: Pinnacle Laboratories
Attn: Mitch Rubenstein, Ph.D.
2709 D Pan American Freeway NE
Albuquerque, NM 87107

Report : 960633-658(649-658)+777(777)

Priority: Standard Written

Status: Final

Sampling Point: River / 310149-06

Samples Submitted: Three drinking water samples

Copies to: None

------------------Collected-------------------			------------------Received-------------------	
Date: 10/28/03	Time: 11:00	By: Client	Date: 10/29/03	Time: 09:15

REPORT SUMMARY

Aluminum, iron and turbidity were detected in the samples submitted for analysis at the concentrations indicated, which are all greater than their current respective SMCLs. None of the other analytes included in the detailed parameter list were detected in the samples submitted for analysis at concentrations which exceeded, or were equivalent to, their current respective ALs, MCLs or SMCLs.

Note: Sample containers were provided by the client.

Note: See attached page for additional comments.

Detailed quantitative results are presented on the following pages.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (574) 233-4777.
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Reviewed By: [signature] Date: 11/7/03

Finalized By: [signature] Date: 11-7-03

Client: Pinnacle Laboratories Report : 960633-658(649-658)+777(777)

Sampling Point: River / 310149-06

GENERAL CHEMISTRY								
PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Analysis Time	Lab Number
Nitrate-Nitrite	353.2	0.1	< 0.1	10	mg/L as N	11/06/03	08:56	960653
Nitrite	353.2	0.01	**0.01**	1	mg/L as N	10/29/03	17:39	960654

PARAMETER	SDWA Method	MRL *	Results	SMCL	Units	Analysis Date	Analysis Time	Lab Number
Alkalinity, Bicarbonate	2320B	1.0	**130**	---	mg CaCO3/L	11/03/03	08:35	960649
Alkalinity, Carbonate	2320B	1.0	< 1.0	---	mg CaCO3/L	11/03/03	08:35	960649
Alkalinity, Hydroxide	2320B	1.0	< 1.0	---	mg CaCO3/L	11/03/03	08:35	960649
Alkalinity, Total	2320B	1.0	**130**	---	mg CaCO3/L	11/03/03	08:35	960649
Chloride	300.0	2.0	**7.4**	250	mg/L	10/29/03	10:18	960649
Color (True)	2120B	5.0	**10**	15	pt/Co units	10/30/03	00:28	960650
Hardness, Total	2340B	0.46	**140**	---	mg CaCO3/L	NA	NA	NA
Nitrogen, Ammonia	4500-NH3 D	0.1	< 0.1	---	mg/L	11/05/03	08:48	960777
Odor	140.1	1.0	< 1.0	3	TON	10/29/03	15:00	960655
Organic Carbon, Dissolved	5310C	0.5	**2.1**	---	mg/L	10/30/03	01:34	960651
Organic Carbon, Total	5310C	0.5	**2.4**	---	mg/L	10/30/03	01:50	960656
Solids, Dissolved (TDS)	2540C	10	**260**	500	mg/L	10/31/03	16:00	960649
Solids, Suspended (TSS)	2540D	10	**35**	---	mg/L	10/31/03	13:00	960649
Sulfate	300.0	5.0	62	250	mg/L	10/29/03	10:18	960649
Turbidity	180.1	1.0	25	1	NTU	10/30/03	01:05	960649
UV Absorbance at 254 nm(filtered)	5910 B	1.0	**0.065**	---	cm-1	10/29/03	16:22	960657
UV Absorbance at 254 nm(unfiltered)	5910 B	1.0	**0.072**	---	cm-1	10/29/03	16:23	960658

Comments:

NA = Not applicable - Result presented is based upon a calculation.

EHL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

Client: Pinnacle Laboratories

Report : 960633-658(649-658)+777(777)

..npling Point: River / 310149-06

METALS							
PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Lab Number
Arsenic	200.8	2.0	< 2.5 †	10	ug/L	10/31/03	960652
Lead	200.8	1.0	< 1.2 †	15 ¥	ug/L	10/31/03	960652

PARAMETER	SDWA Method	MRL *	Results	SMCL	Units	Analysis Date	Lab Number
Aluminum	200.8	2.0	**930**	50 - 200	ug/L	11/03/03	960652
Calcium	200.7	0.1	**42**	---	mg/L	11/04/03	960652
Copper	200.8	1.0	**3.9**	1000	ug/L	10/31/03	960652
Iron	200.7	0.02	**0.64**	0.3	mg/L	11/04/03	960652
Magnesium	200.7	0.1	**8.3**	---	mg/L	11/04/03	960652
Manganese	200.8	2.0	**30**	50	ug/L	10/31/03	960652
Potassium	200.7	0.2	**3.1**	---	mg/L	11/05/03	960652
Sodium	200.7	0.1	**24**	---	mg/L	11/05/03	960652

Comments:

¥ An Action Limit (AL) of 15 ug/L has been established for lead. The AL is the maximum allowable concentration of lead in public drinking water supplies when measured at selected consumer taps. Under a complex set of federal guidelines, a public water supplier must initiate remedial action if the concentration of 10% of the consumer tap lead measurements exceeds 15 ug/L.

† Result presented is based upon a dilution factor of 1.25.

EHL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

Pinnacle Laboratories, Inc. Interlab Chain of Custody

Date: 10/28/03 Page: 1 of

Network Project Manager: Jacinta Tenorio

Pinnacle Laboratories, Inc.
2709-D Pan American Freeway, NE
Albuquerque, NM 87107
(505) 344-3777 Fax (505) 344-4413

Please filter the samples w/ * ASAP!

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Metals (8) RCRA	TCLP RCRA (8) Metals	Metals-13 PP List	Metals-TAL (23 Metals)	Dissolved Fe, Mn, Pb (6010)	Al, As, Ca, Cu, Fe, Pb, Mg, Mn, K, Na	TOC, DOC*	Gen Chemistry: NO2+NO3	Alk+Bicarb/Carb, Cl, SO4, TDS	TKN, NH3, Color, Threshold odor	~~Volatile Organics GC/MS (8260)~~	TDS, TSS, Turbidity	UV Absorbs (Filtered)*	Pesticides/PCB (608/8081/8082)	Herbicides (615/8151)	PNA (8310)/8270 SIMS	8260 (TCLP 1311) ZHE	UV Absorbs (Unfiltered)	Base/Neutral Acid Compounds GC/MS (625/8270)	Uranium (ICP-MS)	~~Radium 226+228~~ Hardness	Gross Alpha/Beta	Al, As, Mn, Fe, Ca	NUMBER OF CONTAINERS
BS/310149 -01	10/28/03	0915	AQ									X	X															
Well 2/310149-02	↓	1000	↓									X															X	pH<1.5
Well 6/310149-03		0945										X															X	
Well 7/310149-04		1010										X															X	
Well 8/310149-05		1020										X															X	
River/310149 -06		1100										X															X	
										X	X	X	X	X		X	X					X			X			

CLIENT PROVIDED SAMPLE CONTAINER

PROJECT INFORMATION	
PROJECT #:	310149
PROJ. NAME:	CDM
QC LEVEL:	STD IV
QC REQUIRED:	MS MSD BLANK
TAT:	STANDARD RUSH!!
DUE DATE:	11/4
RUSH SURCHARGE:	—
CLIENT DISCOUNT:	—
SPECIAL CERTIFICATION REQUIRED:	YES NO

COMMENTS:

SAMPLE RECEIPT	
Total Number of Containers	
Chain of Custody Seals	
Received Intact?	
Received Good Cond./Cold	
LAB NUMBER:	

SAMPLES SENT TO:	
PENSACOLA - STL-FL	
ESL - OR	
ATEL - AZ	
ATEL - MARION	
ATEL - MELMORE	
EHL	X
GEL	
U OF MIAMI	
WCAS	
WOHL	

	1.	2.
RELINQUISHED BY:	Signature: Francine Tenorio Time: 1700	Signature: Time:
	Printed Name: Francine Tenorio Date: 10/28/03	Printed Name: Date:
	Pinnacle Laboratories, Inc.	Company
RECEIVED BY:	Signature: Time:	Signature: L. Merrill Time: 0915 AM
	Printed Name: Date:	Printed Name: L. Merrill Date: 10/29/03
	Company	Company

Environmental Health Laboratories
The Nation's Drinking Water Laboratory
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ORDER # 90045

CHAIN OF CUSTODY RECORD

PAGE ____ OF ____

CLIENT/COMPANY ORDERING TEST	SAMPLER (Signature)	STATE (of Sample Origin)	PWS ID#	PROJECT NAME	PO#
Pinnacle		NM			
COMPLIANCE MONITORING? YES NO		POPULATION SERVED:	SOURCE WATER:		

EHL LAB#	COLLECTION DATE	COLLECTION TIME	AM/PM	SAMPLING SITE	TEST NAME	SAMPLE REMARKS	Chlorinated Yes	Chlorinated No	# OF CONTAINERS	MATRIX CODE	TURNAROUND TIME
960633	10/23/03	0915	AM	BS / 310149-01	Fe Mn Co As Al	pH=1.5			1		
960634	↓	↓	AM PM	↓	Nitrate - Nitrite	↓			↓		
960635			AM PM		Nitrite						
960636			AM PM		TDS SO4 Cl Bicarb, Carb, Hydrox, Total Alk						
960637		1000	AM	Well 2 / 310149-02	Fe Al Mn Ca Cs	pH=1.5					
960638		↓	AM PM	↓	Nitrate - Nitrite	↓					
960639			AM PM		Nitrite						
960640		0945	AM	Well 6 / 310149-03	Fe Al Mn Cs Ca	pH=1.5					
960641		↓	AM PM	↓	Nitrate Nitrite	↓					
960642			AM PM		Nitrite						
960643		1010	AM	Well 7 / 310149-04	Fe Al Mn Cs Ca	pH=1.5					
960644		↓	AM PM	↓	Nitrate - Nitrite	↓					
960645	↓		AM PM		Nitrite				↓		

FIELD COMMENTS: CARRIER ____ AIRBILL NO. ____ COOLER NO. ____ DATE SHIPPED ____

RELINQUISHED BY: (Signature)	DATE	TIME (AM/PM)	RECEIVED BY: (Signature)	DATE	TIME (AM/PM)
RELINQUISHED BY: (Signature)	DATE	TIME (AM/PM)	RECEIVED BY: (Signature)	DATE	TIME (AM/PM)
RELINQUISHED BY: (Signature)	DATE	TIME (AM/PM)	RECEIVED FOR LABORATORY BY:	DATE	TIME (AM/PM)
			[signature]	10/24/03	0815 AM

LAB RESERVES THE RIGHT TO RETURN UNUSED PORTIONS OF NON-AQUEOUS SAMPLES TO CLIENT.

LAB COMMENTS
wlt IN HOUSE COC

CONDITIONS UPON RECEIPT: (Check One) ☒ Iced ☐ Ambient or 4 °C Upon Receipt

MATRIX CODES:

TURN-AROUND TIME (TAT) - SURCHARGES

SW = STANDARD WRITTEN (15 WORKING DAYS) 0%
RV* = RUSH (5 WORKING DAYS) VERBAL 50%
RW* = RUSH (5 WORKING DAYS) WRITTEN 75%
*-Please Call, Expedited services not available for all services.

IV* = IMMEDIATE (3 WORKING DAYS) VERBAL **100%**
IW* = IMMEDIATE (3 WORKING DAYS) WRITTEN **125%**
SP* = WEEKEND, HOLIDAY **Call**

STAT* = LESS THAN 48 HOURS **Call**
Samples received unannounced with less than 48 hours holding time remaining may be subject to additional surcharges.

Environmental Health Laboratories
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ORDER # 50045

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CHAIN OF CUSTODY RECORD

PAGE ____ OF ____

CLIENT/COMPANY ORDERING TEST: Pinnacle
COMPLIANCE MONITORING? YES NO
SAMPLER (Signature):
STATE (of Sample Origin):
PWS ID#:
POPULATION SERVED:
SOURCE WATER:
PROJECT NAME:
PO#:

EHL LAB#	COLLECTION DATE	COLLECTION TIME	SAMPLING SITE	TEST NAME	SAMPLE REMARKS	Chlorinated Yes	Chlorinated No	# OF CONTAINERS	MATRIX CODE	TURNAROUND TIME
960646	10/28/03	10:20 AM	Well 8 /310149-05	Al As Mn Fe Ca	pH=1.5			1		
960647		AM PM		Nitrate - Nitrite						
960648		AM PM		Nitrite						
960649		11:00 AM	River /310149-06	Hydrox Bicarb/Carb T Alk, Turb	SO4 Cl TDS TSS			2		
960650		AM PM		color				1		
960651		AM PM		DOC				2		
960652		AM PM		Fe K T Hard Mn Al As Pb Na Cu Ca Mg	pH=1.5			1		
960653		AM PM	OK to pour	Nitrate - Nitrite				1		
960654		AM PM	off from sample	Nitrite				1		
960655		AM PM	960649	Odor				1		
960656		AM PM		TOC	pH=1.5			2		
960657		AM PM		UV filt				1		
960658		AM PM		UV unfilt				1		
960727				Ammonia				1		

FIELD COMMENTS: CARRIER ________ AIRBILL NO. ________ COOLER NO. ________ DATE SHIPPED ________

RELINQUISHED BY: (Signature)	DATE	TIME	RECEIVED BY: (Signature)	DATE	TIME
		AM PM			AM PM
		AM PM			AM PM
		AM PM	RECEIVED FOR LABORATORY BY: [signature]	10/28/03	0915 AM PM

LAB RESERVES THE RIGHT TO RETURN UNUSED PORTIONS OF NON-AQUEOUS SAMPLES TO CLIENT.

LAB COMMENTS
wet
IN HOUSE COC

CONDITIONS UPON RECEIPT: (Check One) ☒ Iced ☐ Ambient or 4 °C Upon Receipt

MATRIX CODES:

TURN-AROUND TIME (TAT) - SURCHARGES

SW = STANDARD WRITTEN (15 WORKING DAYS)	0%	**IV*** = IMMEDIATE (3 WORKING DAYS) VERBAL	**100%**
RV* = RUSH (5 WORKING DAYS) VERBAL	50%	**IW*** = IMMEDIATE (3 WORKING DAYS) WRITTEN	**125%**
RW* = RUSH (5 WORKING DAYS) WRITTEN	75%	**SP*** = WEEKEND, HOLIDAY	**Call**

*-Please Call, Expedited services not available for all services.

STAT* = LESS THAN 48 HOURS **Call**
Samples received unannounced with less than 48 hours holding time remaining may be subject to additional surcharges.

PINNACLE LABORATORIES

Pinnacle Laboratories Inc.

CHAIN OF COUSTODY

DATE: 10/28/03 PAGE: 1 OF 2

PLI Accession #: 310149

SHADED AREAS ARE FOR LAB USE ONLY

PLEASE FILL THIS FORM IN COMPLETELY.

PROJECT MANAGER: Teresa Brooks
COMPANY: CDM INC
ADDRESS:
PHONE:
FAX:
BILL TO: Same
COMPANY:
ADDRESS:

SAMPLE ID	DATE	TIME	MATRIX	LAB I.D.	Gross alpha/Beta	Ra 226/228 + uranium	NO3/NO2	Metals Al, As, Mn, Fe, Ca	Alk., TDS, Cl SO4	TDS, TSS, Turb.	TOC	DOC	UV absorbs (filtered)	# Containers
BS	10/28	0915	AQ	01	X	X	X	X	X					6
Well 2		1000		02	X	X	X	X						5
Well 6		0945		03	X	X	X	X						5
Well 7		1010		04	X	X	X	X						5
Well 8		1020		05	X	X	X	X						5
River		1100		06	X	X				X	X	X	X	14

PROJECT INFORMATION
PROJ. NO.: 1257-37754
PROJ. NAME: Santa Fe
P.O. NO.:
SHIPPED VIA:

SAMPLE RECEIPT
NO. CONTAINERS: 36
CUSTODY SEALS: Y/N/NA
RECEIVED INTACT: Yes
BLUE ICE/ICE: 3.3°C - Direct From Field.

PRIOR AUTHORIZATION IS REQUIRED FOR RUSH PROJECTS
(RUSH) ☐ 24HR ☐ 72HR ☐ 1 WEEK (NORMAL) ☑
CERTIFICATION REQUIRED ☐ NM ☐ SDWA ☐ OTHER
METHANOL PRESERVATION ☐
COMMENTS: FIXED FEE ☐

RELINQUISHED BY: 1.
Signature: Randall Robins Time: 1600
Printed Name: Date: 10/28/03
Company: CDM
See reverse side (Force Majeure)

RELINQUISHED BY: 2.
Signature: Time:
Printed Name: Date
Company:

RECEIVED BY: 1.
Signature: Time:
Printed Name: Date
Company:

RECEIVED BY: 2.
Signature: Time: 1610
Printed Name: Date: 10/28
Pinnacle Laboratories Inc

PINNACLE LABORATORIES

Pinnacle Laboratories Inc.

CHAIN OF CUSTODY

DATE: 10/28/03 PAGE: 2 OF 2

PLI Accession #: 310099

SHADED AREAS ARE FOR LAB USE ONLY.

PROJECT MANAGER: Teresa Brooks
COMPANY: CDM Inc
ADDRESS:
PHONE:
FAX:
BILL TO: Same
COMPANY:
ADDRESS:

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB I.D.	UV absorbs (unfiltered)	Threshold Odor	NO3, TKN, NH3	Color	Alk, Cl, NO2, SO4 (Bicarb/Carb)	Metals, Hardness Al, As, Ca, Cu, Fe, Pb, Mg, Mn, K, Na				# CONTAINERS
River	10/28	1100	AQ	06	X	X	X	X	X	X				8

14 mc

PROJECT INFORMATION
PROJ. NO.: 1257-37754
PROJ. NAME: Santa Fe
P.O. NO.:
SHIPPED VIA:

SAMPLE RECEIPT
NO. CONTAINERS: 8
CUSTODY SEALS: Y N NA
RECEIVED INTACT: Y
BLUE ICE/ICE: 1.3°C

PRIOR AUTHORIZATION IS REQUIRED FOR RUSH PROJECTS
(RUSH) ☐ 24HR ☐ 72HR ☐ 1 WEEK (NORMAL) ☒
CERTIFICATION REQUIRED ☐ NM ☐ SDWA ☐ OTHER
METHANOL PRESERVATION ☐
COMMENTS: FIXED FEE ☐

Direct From Field

RELINQUISHED BY: 1
Signature: [signature] Time: 1600
Printed Name: Date: 10/28/03
Company: CDM
See reverse side (Force Majeure)

RECEIVED BY: 1
Signature: Time:
Printed Name: Date:
Company:

RELINQUISHED BY: 2
Signature: Time:
Printed Name: Date:
Company:

RECEIVED BY: (LAB) 2
Signature: [signature] Time: 1610
Printed Name: [signature] Date: 10/28
Pinnacle Laboratories Inc.

PLEASE FILL THIS FORM IN COMPLETELY.

PINNACLE LABORATORIES

2709-D Pan American Freeway NE
Albuquerque, New Mexico 87107
Phone (505) 344-3777
Fax (505) 344-4413

PL I.D. **310149**

December 9, 2003

Camp, Dresser & McKee, Inc.
121 Tijeras Ave NE, Suite 1000
Albuquerque, NM 87102

RECEIVED
DEC 10 2003
CAMP DRESSER & McKEE INC.
ALBUQUERQUE

Project Name/Number: SANTA FE 1257-37754

Attention: Teresa Brooks

On **10/28/03**, Pinnacle Laboratories Inc., (ADHS License No. AZ0643), received a request to analyze **aqueous** samples. The samples were analyzed with EPA methodology or equivalent methods. The results of these analyses and the quality control data, which follow each set of analyses, are enclosed.

This report is being reissued in part to include TKN analyses, which was inadvertently omitted from the original report dated December 1, 2003. We apologize for any inconvenience this may have caused.

Radiological Chemistry analyses were performed by General Engineering Laboratories, LLC. Charleston, SC.

All remaining analyses were performed by Environmental Health Laboratories, Inc. South Bend, IN.

If you have any questions or comments, please do not hesitate to contact us at (505) 344-3777.

H. Mitchell Rubenstein, Ph.D.
General Manager

MR:jt

Enclosure

PINNACLE LABORATORIES

2709-D Pan American Freeway NE
Albuquerque, New Mexico 87107
Phone (505) 344-3777
Fax (505) 344-4413

CLIENT	: CAMP, DRESSER & McKEE, INC.	DATE RECEIVED	: 10/28/03
PROJECT #	: 1257-37754		
PROJECT NAME	: SANTA FE	REPORT DATE	: 12/09/03

PL ID: 310149

	PINNACLE ID #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTED
01	310149-01	BS	AQUEOUS	10/28/03
02	310149-02	WELL 2	AQUEOUS	10/28/03
03	310149-03	WELL 6	AQUEOUS	10/28/03
04	310149-04	WELL 7	AQUEOUS	10/28/03
	310149-05	WELL 8	AQUEOUS	10/28/03
	310149-06	RIVER	AQUEOUS	10/28/03

---TOTALS---

MATRIX	#SAMPLES
AQUEOUS	6

Environmental Health Laboratories
The Nation's Drinking Water Laboratory

110 S. Hill Street
South Bend, IN 46617
574.233.4777
800.332.4345
Fax: 574.233.8207
www.ehl.cc

NELAP NARRATIVE PAGE

Client: Pinnacle Laboratories

Report #: 960778NP

EHL is a NELAP accredited laboratory. All reported results meet the requirements of the NELAP standards.

EHL contact person: Jim Van Fleit

NELAP requires complete reporting of deviations from method requirements, regardless of the suspected impact on the data. Quality control failures not reported within the report summary are noted here.

There were no quality control failures.

Reviewed By: Reporter — Date: 4/22/03

Finalized By: James ... — Title: Project Manager — Date: 11/24/03

EHL-RF-147-01
Effective Date: July 15, 2002

110 S. Hill Street
South Bend, IN 46617
574.233.4777
800.332.4345
Fax: 574.233.8207
www.ehl.cc

Environmental Health Laboratories
The Nation's Drinking Water Laboratory

LABORATORY REPORT

Client: Pinnacle Laboratories
Attn: Mitch Rubenstein, PhD.
2709 D Pan American Freeway NE
Albuquerque, NM 87107

Report : 960778

Priority: Standard Written

Status: Final

Sampling Point: River / 310149-06

Samples Submitted: One drinking water sample

Copies to: None

-----------------Collected-------------------
Date: 10/28/03 Time: 11:00 By: Client

-----------------Received-------------------
Date: 10/29/03 Time: 09:15

REPORT SUMMARY

Nitrogen, Kjeldahl was not detected in the sample submitted for analysis.

Note: Sample container was provided by the client.

Note: See attached page for additional comments.

Detailed quantitative results are presented on the following page.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (574) 233-4777.

Reviewed By: Steve Dengy Reporter Date: 11/22/03

Finalized By: James Osbrne Project Manager Date: 11/24/03

Client: Pinnacle Laboratories

Report : 960778

ampling Point: River / 310149-06

GENERAL CHEMISTRY							
PARAMETER	SDWA Method	MRL *	Results	MCL	Units	Analysis Date	Lab Number
Nitrogen, Kjeldahl	351.2	1.0	< 1.0	---	ppm	11/17/03	960778

Comments:

Nitrogen, Kjeldahl analysis performed by Sherry Laboratories, Columbus, IN

*HL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

Pinnacle Laboratories, Inc. — cle Laboratories, Inc.

Interlab ain of Custody

7004

Date: 10/28/03 Page: 1 of 1

Network Project Manager: Jacinta Tenorio

Pinnacle Laboratories, Inc.
2709-D Pan American Freeway, NE
Albuquerque, NM 87107
(505) 344-3777 Fax (505) 344-4413

Please filter the samples w/ * ASAP!

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Metals (8) RCRA	TCLP RCRA (8) Metals	Metals-13 PP List	Metals-TAL (23 Metals)	Dissolved Fe, Mn, Pb (6010)	Al, As, Ca, Cu, Fe, Pb, Mg, Mn, K, Na	TOC, DOC*	Gen Chemistry: NO_2+NO_3	Alk+Bicarb/Carb, Cl, SO_4, TDS	TKN, NH_3, Color, Threshold odor	~~Volatile Organics GC/MS (8260)~~	TDS, TSS, Turbidity	UV Absorbs (Filtered)*	Pesticides/PCB (608/8081/8082)	Herbicides (615/8151)	PNA (8310)/8270 SIMS	8260 (TCLP 1311) ZHE	UV Absorbs (Unfiltered)	Base/Neutral Acid Compounds GC/MS (625/8270)	Uranium (ICP-MS)	~~Radium 226/228~~ Hardness	Gross Alpha/Beta	~~Metals~~ Al, As, Mn, Fe, Ca	NUMBER OF CONTAINERS
BS/310149 -01	10/28/03	0915	AQ									X	X															
Well 2/310149-02	↓	1000	↓									X															X	pH<1.5
Well 6/310149-03		0945										X															X	
Well 7/310149-04		1010										X															X	
Well 8/310149-05		1020										X															X	
River/310149 -06	↓	1100	↓									X															X	
										X	X	X	X	X		X	X					X			X			

CLIENT PROVIDED SAMPLE CONTAINER

PROJECT INFORMATION	
PROJECT #:	310149
PROJ. NAME:	CDM
QC LEVEL:	STD IV
QC REQUIRED:	MS MSD BLANK
TAT:	STANDARD RUSH!!
DUE DATE:	11/4
RUSH SURCHARGE:	—
CLIENT DISCOUNT:	—
SPECIAL CERTIFICATION REQUIRED:	YES NO

COMMENTS:

SAMPLE RECEIPT	
Total Number of Containers	
Chain of Custody Seals	
Received Intact?	
Received Good Cond./Cold	
LAB NUMBER:	

SAMPLES SENT TO:	
PENSACOLA - STL-FL	
ESL - OR	
ATEL - AZ	
ATEL - MARION	
ATEL - MELMORE	
EHL	X
GEL	
U OF MIAMI	
WCAS	
WOHL	

RELINQUISED BY: 1.
Signature: Francine Tovino Time: 1700
Printed Name: Francine Tovino Date: 10/28/03
Pinnacle Laboratories, Inc.

RELINQUISED BY: 2.
Signature: Time:
Printed Name: Date:
Company

RECEIVED BY: 1.
Signature: Time:
Printed Name: Date:
Company

RECEIVED BY: 2.
Signature: L. Merrill Time: 09:15 AM
Printed Name: L. Merrill Date: 10/29/03
Company

Environmental Health Laboratories
The Nation's Drinking Water Laboratory
110 S. Hill Street
South Bend, IN 46617
(800) 332-4345
Fax (574) 233-8207
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Division of Underwriters Laboratories Inc.®

See back for example doc

ORDER # 90045

SHADED AREA FOR LAB USE ONLY

CHAIN OF CUSTODY RECORD

PAGE ______ OF ______

CLIENT/COMPANY ORDERING TEST	SAMPLER (Signature)	STATE (of Sample Origin)	PWS ID#	PROJECT NAME	PO#
Pinnacle					
COMPLIANCE MONITORING? YES NO		POPULATION SERVED:	SOURCE WATER:		

EHL LAB#	COLLECTION DATE	COLLECTION TIME	SAMPLING SITE	TEST NAME	SAMPLE REMARKS	Chlorinated Yes	Chlorinated No	# OF CONTAINERS	MATRIX CODE	TURNAROUND TIME
960778	10/23/03	11:00 AM PM	River/310145-00	TKN				1		
		AM PM								
		AM PM								
		AM PM								
		AM PM								
		AM PM								
		AM PM								
		AM PM								
		AM PM								
		AM PM								
		AM PM								
		AM PM								
		AM PM								

FIELD COMMENTS: CARRIER ______ AIRBILL NO. ______ COOLER NO. ______ DATE SHIPPED ______

RELINQUISHED BY: (Signature)	DATE	TIME	RECEIVED BY: (Signature)	DATE	TIME
		AM PM			AM PM

RELINQUISHED BY: (Signature)	DATE	TIME	RECEIVED BY: (Signature)	DATE	TIME
		AM PM			AM PM

RELINQUISHED BY: (Signature)	DATE	TIME	RECEIVED FOR LABORATORY BY:	DATE	TIME
		AM PM	[signature]	10/29/03	0915 AM PM

LAB RESERVES THE RIGHT TO RETURN UNUSED PORTIONS OF NON-AQUEOUS SAMPLES TO CLIENT.

LAB COMMENTS
wet
IN HOUSE COC

CONDITIONS UPON RECEIPT: (Check One)
☒ Iced ☐ Ambient or 4 °C Upon Receipt

MATRIX CODES:

TURN-AROUND TIME (TAT) - SURCHARGES

SW = STANDARD WRITTEN (15 WORKING DAYS) 0%
RV* = RUSH (5 WORKING DAYS) VERBAL 50%
RW* = RUSH (5 WORKING DAYS) WRITTEN 75%
*-Please Call, Expedited services not available for all services.

IV* = IMMEDIATE (3 WORKING DAYS) VERBAL **100%**
IW* = IMMEDIATE (3 WORKING DAYS) WRITTEN **125%**
SP* = WEEKEND, HOLIDAY **Call**

STAT* = LESS THAN 48 HOURS **Call**
Samples received unannounced with less than 48 hours holding time remaining may be subject to additional surcharges.

PINNACLE LABORATORIES

2709-D Pan American Freeway NE
Albuquerque, New Mexico 87107
Phone (505) 344-3777
Fax (505) 344-4413

RECEIVED

DEC 10 2003

CAMP DRESSER & McKEE INC.
ALBUQUERQUE

PL I.D. **311045**

December 9, 2003

CDM, Inc.
121 Tijeras Ave NE, Suite 1000
Albuquerque, NM 87102

Project Name/Number: BENCH SCALE TESTING 1257.37755.1E

Attention: Theresa Brooks

On **11/11/03**, Pinnacle Laboratories Inc., (ADHS License No. AZ0643), received a request to analyze **aqueous** samples. The samples were analyzed with EPA methodology or equivalent methods. The results of these analyses and the quality control data, which follow each set of analyses, are enclosed.

All analyses were performed by Environmental Health Laboratories, Inc. South Bend, IN.

If you have any questions or comments, please do not hesitate to contact us at (505) 344-3777.

H. Mitchell Rubenstein, Ph.D.
General Manager

MR:jt

Enclosure

PINNACLE LABORATORIES

2709-D Pan American Freeway NE
Albuquerque, New Mexico 87107
Phone (505) 344-3777
Fax (505) 344-4413

CLIENT	: CAMP, DRESSER & McKEE, INC.	DATE RECEIVED	: 11/11/03
PROJECT #	: 1257.37755.1E		
PROJECT NAME	: BENCH SCALE TESTING	REPORT DATE	: 12/09/03

PL ID: 311045

	PINNACLE ID #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTED
01	311045-01	FeCl 07-0.5	AQUEOUS	11/10/03
02	311045-02	FeCl 07-1.0	AQUEOUS	11/10/03
03	311045-03	FeCl 04-0.5	AQUEOUS	11/10/03
04	311045-04	Alum 17-0.5	AQUEOUS	11/10/03
	311045-05	Alum 14-0.5	AQUEOUS	11/10/03
	311045-06	PAX 3-0.65	AQUEOUS	11/10/03

---TOTALS---

MATRIX	#SAMPLES
AQUEOUS	6

Environmental Health Laboratories
The Nation's Drinking Water Laboratory

110 S. Hill Street
South Bend, IN 46617
574.233.4777
800.332.4345
Fax: 574.233.8207
www.ehl.cc

NELAP NARRATIVE PAGE

Client: Pinnacle Laboratories

Report #: 966035-41NP

EHL is a NELAP accredited laboratory. All reported results meet the requirements of the NELAP standards.

EHL contact person: James DeBoe

NELAP requires complete reporting of deviations from method requirements, regardless of the suspected impact on the data. Quality control failures not reported within the report summary are noted here.

There were no quality control failures.

[signature]	Reporter	11/18/03
Reviewed By	Title	Date
[signature]	P.M.	11-21-03
Finalized By	Title	Date

Environmental Health Laboratories
The Nation's Drinking Water Laboratory

110 S. Hill Street
South Bend, IN 46617
574.233.4777
800.332.4345
Fax: 574.233.8207
www.ehl.cc

LABORATORY REPORT

Client: Pinnacle Laboratories
Attn: Mitch Rubenstein, PhD.
2709 D Pan American Freeway NE
Albuquerque, NM 87107

Report#: 966035-41

Priority: Standard Written

Status: Final

Project/Site: 311045 / CDM

Samples Submitted: Seven drinking water samples

Copies to: None

Collected: 11/10/03 By: Client Received: 11/12/03

REPORT SUMMARY

Seven drinking water samples were submitted for multiple parameter analyses.

Note: Sample containers were provided by the client.

Note: See attached page for additional comments.

Detailed quantitative results are presented on the following page.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (574) 233-4777.

Note: This report may not be reproduced, except in full, without written approval from Environmental Health Laboratories (EHL).

REVIEWED BY: [signature] Reporter DATE: 11/18/03

FINALIZED BY: [signature] P.M. DATE: 11-21-03

Client: Pinnacle Laboratories

Report#: 966035-41

MANGANESE—Drinking Water

Lab #	Site Description	SMCL	MRL	Results	
966040	311045-01	50	2.0	33	ug/L
966041	311045-02	50	2.0	120	ug/L

Analyzed: 11/12/03 Analyst: TO Method #: 200.8

TOTAL ORGANIC CARBON(TOC)—Drinking Water

Lab #	Site Description	MRL	Results	
966035	FeCl 07-0.5 / 311045-01	0.5	2.2	mg/L
			2.2	mg/L
966036	FeCl 04-0.5 / 311045-03	0.5	2.4	mg/L
			2.2	mg/L
966037	Alum 17-0.5 / 311045-04	0.5	2.0	mg/L
			1.9	mg/L
966038	Alum 14-0.5 / 311045-05	0.5	1.9	mg/L
			1.9	mg/L
966039	Pax 3-0.65 / 311045-06	0.5	1.9	mg/L
			1.9	mg/L

Analyzed: 11/13/03 Analyst: NB Method #: 5310 C

Client: Pinnacle Laboratories

Report#: 966035-41

REFERENCES AND DEFINITIONS OF TERMS

Disinfectants/Disinfection By-Products (D/DBP) Analyses in Drinking Water

References:
1. EPA-600/4-79-020
Methods for Chemical Analysis of Water and Wastes, 1983
2. Standard Methods For the Examination of Water and Wastewater
Vol. 19, 1995
3. Methods for the Determination of Organic Compounds in Drinking
Water: EPA /600/4/4-88/039

Metals in Drinking Water

Analytical Technique: Inductively Coupled Plasma - Mass Spectrometry
MS = ICP-MS

Reference: EPA 600/4-79-020
Methods for Chemical Analysis of Water and Wastes

SMCL (Secondary Maximum Contaminant Levels) are concentrations which represent a reasonable goal for drinking water quality, but which are not federally enforceable. These goals generally reflect aesthetic considerations.

MRL = EHL's Minimum Reporting Limit

< = "less than." This number is the lowest reportable value by the procedure used for analysis.

1 ug/L = 1 microgram per liter = 1 part per billion (ppb)

1 mg/L = 1 milligram per liter = 1 part per million (ppm)

Pinnacle Laboratories, Inc. — Interlab Chain of Custody

Date: 11/11/03 Page: 1 of

Network Project Manager: Jacinta Tenorio

Pinnacle Laboratories, Inc.
2709-D Pan American Freeway, NE
Albuquerque, NM 87107
(505) 344-3777 Fax (505) 344-4413

Dissolved Mn has been filtered & preserved.

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Metals (8) RCRA	TCLP RCRA (8) Metals	Metals-13 PP List	Metals-TAL (23 Metals)	Dissolved Fe, Mn, Pb (6010)	Dissolved Mn	TOC	Gen Chemistry:			Volatile Organics GC/MS (8260)	BOD	COD	Pesticides/PCB (608/8081/8082)	Herbicides (615/8151)	PNA (8310)/8270 SIMS	8260 (TCLP 1311) ZHE		Base/Neutral Acid Compounds GC/MS (625/8270)	Uranium (ICP-MS)	Radium 226+228	Gross Alpha/Beta	TO-14	NUMBER OF CONTAINERS
FeCl 07-0.5/311045-01	11/10/03	1615	AQ	966035						~~X~~	X	pH=1.5																
FeCl 07-1.0/311045-02	↓	↓	↓							~~X~~																		
FeCl 04-0.5/311045-03	↓	↓	↓	966036							X	pH=1.5																
Alum 17-0.5/311045-04	↓	1815	↓	966037							X	↓																
Alum 14-0.5/311045-05	↓	1818	↓	966038							X	↓																
PAX 3-0.65/311045-06	↓	1700	↓	966039							X	↓																
311045-01		1615		966040						x		pH<2 SS																
311045-02		↓		966041						x		↓																

CLIENT PROVIDED SAMPLE CONTAINER

PROJECT INFORMATION	
PROJECT #:	311045
PROJ. NAME:	CDM
QC LEVEL:	STD. IV
QC REQUIRED:	MS MSD BLANK
TAT:	STANDARD RUSH!!
DUE DATE:	11/25
RUSH SURCHARGE:	—
CLIENT DISCOUNT:	—
SPECIAL CERTIFICATION REQUIRED:	YES NO

SAMPLE RECEIPT	
Total Number of Containers	
Chain of Custody Seals	
Received Intact?	
Received Good Cond./Cold	
LAB NUMBER:	

COMMENTS:

SAMPLES SENT TO:	
PENSACOLA - STL-FL	
ESL - OR	
ATEL - AZ	
ATEL - MARION	
ATEL - MELMORE	
EHL	X
GEL	
U OF MIAMI	
WCAS	
WOHL	

RELINQUISED BY: 1.	RELINQUISED BY: 2.
Signature: Francine Tenorio Time: 1700	Signature: Time:
Printed Name: Francine Tenorio Date: 11/11/03	Printed Name: Date:
Pinnacle Laboratories, Inc.	Company

RECEIVED BY: 1.	RECEIVED BY: 2.
Signature: Time:	Signature: L. Merrill Time: 12:30 pm
Printed Name: Date:	Printed Name: L. Merrill Date: 11/12/03
Company	Company EHL

4°C

PINNACLE LABORATORIES

Pinnacle Laboratories Inc.

CHAIN OF CUSTODY

DATE: 11/11/03 PAGE: 1 OF 1

PLI Accession #: 311045

PROJECT MANAGER: Theresa Brooks

COMPANY: CDM

ADDRESS:

PHONE:

FAX:

BILL TO:

COMPANY:

ADDRESS:

ANALYSIS REQUEST

SAMPLE ID	DATE	TIME	MATRIX	LAB ID	Petroleum Hydrocarbons (418.1) TRPH	(MOD.8015) Diesel/Direct Inject	TOC	(M8015) Gas/Purge & Trap	8021 (BTEX)/8015 (Gasoline) MTBE	8021 (BTEX) □MTBE □TMB □PCE	8021 (TCL)	8021 (EDX)	8021 (HALO)	8021 (CUST)	504.1 EDB □/DBCP □	Mn - dissolved	8260 (TCL) Volatile Organics	8260 (Full) Volatile Organics □PBMS	8260 (CUST) Volatile Organics	8260 (Landfill) Volatile Organics	Pesticides/PCB (608/8081/8082)	Herbicides (615/8151)	Base/Neutral/Acid Compounds GC/MS (625/8270)	Polynuclear Aromatics (610/8310/8270-SIMS)	General Chemistry:		Priority Pollutant Metals (13)	Target Analyte List Metals (23)	RCRA Metals (8)	RCRA Metals by TCLP (Method1311)	Metals:		NUMBER OF CONTAINERS
FeCl 07-0.5	10/10	1615	Water	01			2									1																	3
FeCl 07-1.0	11/10	1615	"	02												1																	1
FeCl 04-0.5	11/10	1615	"	03			2																										2
Alum 17-0.5	11/10	1815	"	04			2																										2
Alum 14-0.5	11/10	1815	"	05			2																										2
PAX 3-0.65	11/10	1700	"	06			2																										2

WEEKEND ANALYSES MAY RESULT IN AN ADDITIONAL SURCHARGE - PLEASE INQUIRE.

PROJECT INFORMATION

PROJ. NO.: 1257377755.1E

PROJ. NAME: Bench Scale Testing

P.O. NO.:

SHIPPED VIA:

SAMPLE RECEIPT

NO. CONTAINERS	12
CUSTODY SEALS	Y N NA
RECEIVED INTACT	Y
BLUE ICE/ICE	NO 16.0

PRIOR AUTHORIZATION IS REQUIRED FOR RUSH PROJECTS

(RUSH) □24hr* □48hr* □72hr* □ 1 WEEK (NORMAL) ☒

*NOT AVAILABLE ON ALL ANALYSES

CERTIFICATION REQUIRED □ NM □ SDWA □ AZ □ OTHER

METHANOL PRESERVATION □ METALS □ TOTAL □ DISSOLVED

COMMENTS:

RELINQUISHED BY: 1.

Signature: [signature] Time: 9:48

Printed Name: Theresa Brooks Date: 11/11/03

Company: CDM

See Reverse side (Force Majeure)

RELINQUISHED BY: 2.

Signature: Time:

Printed Name: Date:

Company:

RECEIVED BY: 1.

Signature: Time:

Printed Name: Date:

Company:

RECEIVED BY: (LAB) 2.

Signature: [signature] Time: 948

Printed Name: Deb Rogalsa Date: 11-11-03

Pinnacle Laboratories Inc.

PLEASE FILL THIS FORM IN COMPLETELY.

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